COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

NOUVELLE SÉRIE

1939

IMPERIAL MYCOLOGICAL
3 JUNE 1939
INSTITUTE

VOLUME XXII

№ 6

ÉDITION DE L'ACADÉMIE DES SCIENCES DE L'URSS
MOSCOU

AVIS AUX AUTEURS

Les «Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS» paraissent tous les dix jours, neuf numéros formant un volume d'environ 500 pages pourvu d'une table des matières.

Les «Comptes Rendus de l'Académie des Sciences de l'URSS» publient des communications courtes précisant l'essentiel des travaux plus volumineux en préparation. Ces articles, ne dépassant pas comme règle dix mille signes typographiques, sont donnés en l'une des trois langues: français, anglais, allemand. Ils embrassent les sciences mathématiques, physiques, naturelles et techniques, reproduisant les résultats de recherches scientifiques actuellement en cours ou à peine achevées qui représentent les plus récentes données de l'investigation scientifique.

Les auteurs ont droit chacun à 25 extraits gratuits.

Les manuscrits doivent être adressés à la Rédaction des «Comptes Rendus»

25 Février

COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

COMITÉ DE RÉDACTION

A. Borissiak, de l'Académie, **A. Fersman**, de l'Académie, **A. Frumkin**, de l'Académie, **A. Richter**, de l'Académie, **S. Wawilow**, de l'Académie

NOUVELLE SÉRIE

7-me année

Paraissant tous les dix jours

1939

VOLUME XXII, № 6

TABLE DES MATIÈRES

Pages

Editorial 291

MATHÉMATIQUES

George Chogoshvili. On the Variation of Betti Numbers of a Moving Level Surface 293

R. O. Kuzmin. Sur la loi de distribution du coefficient de correlation dans les tirages d'un ensemble normal 298

M. Pototzky. Une famille de congruences à surfaces développables correspondantes et aux points focaux situés sur les rayons correspondants des deux congruences 302

G. Tolstoff. Une remarque sur le théorème de D. Th. Egoroff 305

PHYSIQUE

V. I. Veksler. On Non-Ionizing Particles in the Penetrating Component of Cosmic Radiation 308

M. A. Bak and N. N. Nikolaevskaja. Gamma-Rays from Radioactive Iodine (I^{128}) 312

PHYSIQUE DU GLOBE

A. I. Lebedinsky. On the Radiative Equilibrium of the Earth Atmosphere 316

CHIMIE

E. S. Sarkisov. Aluminium and Chromium Coatings Obtained from Vapours of Their Salts 318

GÉOCHIMIE

I. P. Novokhatsky and **S. K. Kalinin.** Spectroscopic Character of the Thermae of the Transilian Alatau (Tyan-Shan) 323

MINÉRALOGIE

T. N. Agafonova and **E. W. Iskül.** Identity of the Inder Ascharite and Camsellite 325

PÉTROGRAPHIE

K. I. Astashenko and **V. A. Moleva.** Zunyite and Zunyite Rock of Karabas 327

GÉOLOGIE

L. Lungershausen. Traces of Glacial Climate in the Older Paleozoic of Podolia 331
L. Lungershausen. Stages of Development of the Dnieper-Donetz Depression 336

GÉNÉTIQUE

A. Shmuck. Scheme of the Chemical Structure of Chromosomes 340
N. N. Medvedev. Studies in Development Genetics. Sensitive Periods and Their Relation to the Problem of the Mechanism of Gene Action in Development 344
G. D. Pratassenja. Production of Polyploid Plants. Haploid and Triploids in *Prunus persica* 348
D. F. Petrov. On the Occurrence of Facultative Pseudogamy in a Triploid Variety of Raspberries, Immer tragende (*R. idaeus*) 352
L. Breslavetz. Polyploids in Rye Induced by X-Rays 354

MORPHOLOGIE ÉVOLUTIONNAIRE

M. M. Kamshilov. Dominance and Selection 358

PHYSIOLOGIE VÉGÉTALE

A. A. Sapehin, Member of the Academy of the Ukrainian SSR. New Data on the Course of Development of the Ear of Wheat 361
K. I. Gavrilov. On the Dynamics of Growth-Substances of the Group B in Plants 365

MÉCANIQUE DU DÉVELOPPEMENT

A. S. Ginsburg. Some Data on the Determination of the Ear in *Triton taeniatus* 370

PHYSIOLOGIE DES ANIMAUX

G. A. Wassiliev and **A. A. Woitkewitsch.** Development and Behaviour of Thyroidectomized Young Rooks (*Corvus frugilegus* L.) 374
H. F. Kushner. Changes in Blood Value of Draft Horses during Work and Rest 380

Rédacteur en chef A. Fersman. Rédacteur S. Bernstein.

En composition 23/II 1939. En impression 1/IV 1939. Nombre de feuilles d'impression 6. Nombre de caractères par feuille d'impression 65.000. Pages 289—384. Format du papier 72×110cm. Tirage 1000. Moscou. Glavlit A 3315. Numéro d'édition 2064. Numéro typographique 499.

Imprimerie № 16. Moscou. Trekhproudnij péréoulok, 9.

SALUT AU XVIII-e CONGRÈS DU PARTI COMMUNISTE (BOLCHÉVIK) DE L'U. R. S. S.

L'Union des Républiques Soviétiques Socialistes a victorieusement réalisé le deuxième plan quinquennal (1933—1937) et est entrée dans une nouvelle période de développement, dans la période d'achèvement de l'édification de la société socialiste sans classes et de passage progressif du socialisme au communisme.

Le troisième plan quinquennal de développement de l'économie nationale de l'U. R. S. S. (1938—1942) prévoit une immense édification dans tous les domaines de notre existence, sur la base de l'amélioration considérable de l'équipement technique de toutes les branches de l'économie nationale, grâce à la large utilisation des derniers progrès de la science et de la technique. Le problème économique fondamental de l'U. R. S. S.: rattraper et dépasser également au point de vue économique les pays capitalistes d'Europe les plus développés, ainsi que les États-Unis, se pose maintenant dans toute son ampleur.

Le troisième plan quinquennal, celui de la chimie, envisage, comme une des tâches principales, la tâche de transformer l'industrie chimique en l'une des branches dirigeantes de l'industrie, de créer de nouvelles branches de synthèse organique, d'assurer la large utilisation des hautes pressions et des méthodes électrochimiques. Les succédanés des métaux non-ferreux devront être largement employés dans toutes les branches de la construction mécanique; les travaux de gazéification de toutes les espèces de combustible recevront un développement considérable et, en particulier, la gazéification souterraine de la houille deviendra une branche industrielle indépendante. Les automates devront être appliqués sur une échelle importante dans tous les domaines de l'industrie des machines.

Vers la fin de la troisième période quinquennale, la Voie Maritime du Nord doit devenir une grande ligne de navigation normale; une voie de transit d'une grande profondeur doit aussi être créée d'Astrakhan à Moscou et des travaux seront exécutés pour la reconstruction de la voie fluviale Volga-Baltique. On développera dans le troisième quinquennat la construction de l'ouvrage le plus grandiose du monde—le réseau hydroélectrique de Kouibychev, d'un débit total de 3.4 millions de kW, qui résoudra, en même temps, le problème de l'irrigation dans le pays d'Outre-Volga et celui de la navigation sur le Volga et la Kama.

L'immense édification prévue par le troisième plan quinquennal exige de nouvelles méthodes plus efficaces de construction et soulève, comme un des problèmes créateurs à l'ordre du jour, l'application énergique des méthodes accélérées de construction.

Le troisième plan quinquennal impose également à l'agriculture des tâches très importantes dont la solution exige un travail scientifique consi-

dérable. Les principaux jalons de cet immense travail créateur sont le développement de la sélection des semences, l'introduction ultérieure de nouveaux assolements, la création d'une solide base fourragère pour l'élevage en progression, l'amélioration radicale de l'élevage des reproducteurs de race, l'achèvement de la mécanisation combinée des travaux agricoles.

Tous les problèmes de l'édification socialiste seront résolus avec succès et le travail scientifique largement développé doit y contribuer de son côté, dans la mesure de ses moyens.

Dans notre pays, la science est mise au service de l'édification de la société socialiste sans classes. Le Parti et le Gouvernement témoignent d'un souci constant pour le développement de la science dans tous les domaines des connaissances humaines. Le réseau des institutions scientifiques s'élargit conformément à l'expansion de la construction, la qualité de leur travail s'améliore et leur rapport avec les exigences pratiques de l'édification devient plus étroit. Le plan du troisième quinquennat envisage de porter à 650 000 le nombre des étudiants des écoles supérieures et des écoles techniques supérieures, tout en prêtant une attention considérable à l'élevation de la qualité de l'enseignement supérieur, à la meilleure préparation scientifique des cadres de constructeurs de la société socialiste.

Conformément à la décision prise par le Gouvernement, le corps de l'Académie des Sciences de l'U.R.S.S. a récemment été complété par de nombreux savants éminents appartenant à toutes les branches de la science et les thèmes de son activité scientifique sont étroitement coordonnés à présent avec les problèmes actuels de l'édification socialiste, en premier lieu, avec les tâches assignées au Pays des Soviets par le quinquennat Stalinien. Le réseau important des institutions spéciales de recherches scientifiques travaille dans la même direction, ainsi que les nombreuses écoles supérieures et écoles techniques supérieures que les nouveaux statuts chargent d'effectuer des travaux de recherches scientifiques devant contribuer à la solution des principaux problèmes de l'édification socialiste.

Il ne saurait y avoir de doute que, dans tous les domaines de la connaissance, la science de notre pays ne réalise de nouveaux progrès importants dans troisième quinquennat et ne prête tout le concours possible à l'édification de la nouvelle société humaine, sous la direction du grand architecte de notre temps, le camarade Staline.

Salut au XVIII-e Congrès du Parti Communiste (bolchévik) de l'U.R.S.S.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

MATHEMATICS

ON THE VARIATION OF BETTI NUMBERS OF A MOVING LEVEL SURFACE

By GEORGE CHOGOSHVILI

(Communicated by I. M. Vinogradow, Member of the Academy, 27. XII. 1938)

Let R be the closure of a bounded domain of a Euclidean or Riemannian n-space, R's boundary B being a regular $(n-1)$-manifold of the class C'''; suppose that on R is defined a non-degenerate function f of the class C'', all critical points of which are contained in the interior of R and which induces on B a non-degenerate function f_b. Thus, R, B, f, f_b satisfy the general boundary conditions, on which, as on all above notions, see the papers referred to at the end of this paper.

Proceeding from these propositions, we shall prove that if *the closed interval* $[a, b]$ *does not contain the critical values of* f *or* f_b, *then the level surfaces* $f=a$ *and* $f=b$ *are homeomorphic; but if the interval contains a single critical value* c, $a<c<b$, *of* f, *assumed by* f *at a critical point of index* k, *whereas* f_b *has no critical values, then for the differences* Δp^i *between the Betti numbers of the same dimensions of the level surfaces* $f=b$ *and* $f=a$ *we have one of the following four cases:*

I. $\Delta p^{k-1}=-1$, $\Delta p^{n-k-1}=1$; II. $\Delta p^{k-1}=-1$, $\Delta p^{n-k}=-1$;
III. $\Delta p^{k}=1$, $\Delta p^{n-k-1}=1$; IV. $\Delta p^{k}=1$, $\Delta p^{n-k}=-1$;

and for all other i: $\Delta p^i=0$ *in every of the four cases. For* $k=0$ *we have always case* III; *for* $k=n$, *always case* II.

Remark I. For $n=2k+1$, $2k$, $2k-1$, when the two pairs of numbers $(k-1,\ k)$ and $(n-k-1,\ n-k)$ overlap, we have the following possibilities:
for $n=2k+1$: either $\Delta p^k=1$ and $\Delta p^{k+1}=-1$, or $\Delta p^k=2$, or $\Delta p^{k-1}=\Delta p^{k+1}=-1$, or $\Delta p^{k-1}=-1$ and $\Delta p^k=1$; for $n=2k$: $\Delta p^{k-1}=\Delta p^k=$ either 0, or 1, or -1; for $n=2k-1$: $\Delta p^{k-1}=-1$ and $\Delta p^k=1$, or $\Delta p^{k-1}=-2$, or $\Delta p^{k-2}=\Delta p^k=1$, or $\Delta p^{k-2}=1$ and $\Delta p^{k-1}=-1$. In particular, for $n=1$: $\Delta p^0=2$ for $k=0$ and $\Delta p^0=-2$ for $k=n$.

The possible variations of Betti numbers of coinciding dimensions must be, consequently, summed up algebraically.

Remark II. If the level surfaces in question represent closed manifolds, then, by Poincaré's duality theorem, only cases II and III remain. In case of coinciding dimensions we apply Remark I; for instance, for $n=2k+1$: either $\Delta p^k=2$ or $\Delta p^{k-1}=\Delta p^{k+1}=-1$.

The construction near the boundary given below enables us to extend the following theorem due to Morse (which was proved by its author for the boundary conditions α) *to general boundary conditions if in the closed interval* (a, b) *there is no critical value of* f, *then the com-*

plexes $f \leqslant b$ *and* $f \leqslant a$ *are homeomorphic; if there is only one critical value* c, $a < c < b$, *corresponding to the critical point of index* k, *then the differences* Δp^i *between the Betti numbers of corresponding dimensions of these complexes are all zero with the only exception that either* $\Delta p^k = 1$ *or* $\Delta p^{k-1} = -1$; *in our case of general boundary conditions we must demand, moreover, that in (a, b) there should be no critical values of* f_b.

For each point p on the boundary B_c of the level surface $f = c$, i. e. on the level surface $f_b = c$, where c is an ordinary value of f_b, there exists such a neighbourhood of p in B_c and such a positive constant d_p that through each point of this neighbourhood there can be drawn a line such that the segments of the length d_p counted from B_c along these lines cover without intersection a neighbourhood of p in $f = c$ (i. e. form a field in this neighbourhood). As such lines we can take for $n = 2$ sufficiently short end segments of the level lines themselves and for $n > 2$ the intersection lines of $f = c$ with the planes normal to B_c; these planes form a field in a sufficiently small neighbourhood of p in R.

Since B_c is compact, there exists a system of a finite number of such neighbourhoods covering B_c and a constant $d_c > 0$, common to all of them; thus, in $f = c$ a border of width d_c is constructed along its boundary B_c; d_c is, in addition, restricted only by the conditions that the border should contain no critical points of f and that none of the two segments of the border (not only any two neighbouring) should intersect each other. Let us take such a $c_1 > c$ that the closed interval $[c_1, c]$ contains no critical values of f_b. Then there exists a number $d_{\bar{c}}^{c_1}$ satisfying the condition $0 < d_{\bar{c}}^{c_1} < d_{\bar{c}}$ for each $c \leqslant \bar{c} \leqslant c_1$; suppose, on the contrary, that for each integer k there exists such a c_k, $c \leqslant c_k \leqslant c_1$, that $f = c_k$ has a border, whose width $d_{c_k} < \frac{1}{k}$; let k_0 be such that for the limit c_0 of these c_k $d_{c_0} > \frac{1}{k_0}$; then, for c_k sufficiently near to c_0 we should have similarly $d_{c_k} > \frac{1}{k_0}$ which contradicts the above assumption. The set of $d_{\bar{c}}^{c_1}$ wide borders of all the level surfaces from c to c_1 inclusively forms a $d_c^{c_1}$ wide border of the domain $c \leqslant f \leqslant c_1$ along that part $B_c^{c_1}$ of its boundary, where $c \leqslant f_b \leqslant c_1$. Let us consider for a certain d, $0 < d < d_c^{c_1}$, the set $[d]_c$ of points of the border of $f = c$ consisting of one point of each segment of the border, namely of the one situated at the distance d from B_c, measured along the segment. Let us consider further the system $\{d\}$ of trajectories orthogonal to $f = \text{const}$ (the representation of trajectories is such that the value of the parameter t at any point of the trajectory is equal to the value of f at that point). Let us choose such a $c' > c$ that none of the trajectories of $\{d\}$ from $t = c$ to $t = c'$ inclusively leaves the constructed border, i. e. does not reach the boundary (if for each $c' > c$ there exists a trajectory of $\{d\}$ which meets B for $t \leqslant c'$, then there should exist a trajectory of $\{d\}$ which meets B at $t = c$; but this is impossible since $[d]_c \cdot B = 0$) and has no point at a greater distance than $d_c^{c_1}$ from $B_c^{c_1}$ (if in $\{d\}$ there exists for every $c' > c$ a trajectory which has a point at a distance $\geqslant d_c^{c_1}$ from B, then already for $t = c$ a trajectory of $\{d\}$, i. e. a point of $[d]_c$, should be at a distance $\geqslant d_c^{c_1}$ from B, which contradicts the definition of d). The set of all points belonging to the trajectories of $\{d\}$ from $t = c$ to $t = c'$ divides the domain $c \leqslant f \leqslant c'$ into two parts. The one, contained in the constructed

border, we shall call the exterior, the other one, the interior. Further, we can choose c' such that no segment should intersect the set $\{d\}$ more than once.

In the same way we choose $c_2 < c$, $d_c^{c_2}$, $c'' < c$ and construct a border situated below $f=c$. Finally, joining the borders above and below $f=c$, we construct the border of the domain $c_2 \leqslant f \leqslant c_1$ along that part $B_{c_2}^{c_1}$ of its boundary, where $c_2 \leqslant f_b \leqslant c_1$, and consider for d, $0 < d < d_c^{c_1}, d_c^{c_2}$, orthogonal trajectories $\{d\}$, which from $t=c'' < c$ to $t=c' > c$ belong to the constructed border.

Let us restrict the c' determined above in such a manner that the closed interval $[c, c']$ should contain no critical values of f. Orthogonal trajectories to $f=\text{const}$ starting from the interior points of $f=c$ and continued up to $t=c'$ cover without intersection the interior part of the domain $c \leqslant f \leqslant c'$.

Mapping the starting point of each trajectory on the end point of the same trajectory, we establish a homeomorphism between the interior parts of $f=c$ and $f=c'$. Let us take an arbitrary point in the exterior part of $f=c$; it belongs to a definite segment of the border of $f=c$ and divides the part of this segment from B_c to $\{d\}$ in a certain ratio k. From the end of this part of the segment there starts a definite trajectory from $\{d\}$; through each point $\bar{c}$, $c \leqslant \bar{c} \leqslant c'$, of this trajectory there passes a certain segment of the border of $f=\bar{c}$. We choose that point of this segment which divides its part from B_c to the considered trajectory in the same ratio k. The set of such points, i. e. of those corresponding to all $\bar{c}$, from c to c', forms a line which we shall call a k-line. The set of all k-lines, i. e. of those corresponding to all exterior points of $f=c$, covers without intersection the exterior part of the domain $c \leqslant f \leqslant c'$. Mapping the original point of each k-line on its end point, we establish a homeomorphism between the exterior parts of $f=c$ and $f=c'$. This homeomorphism continues the former, and thus we get a topological mapping of the whole level surface $f=c$ on the surface $f=c'$. Similarly we find such a $c'' < c$, that $f=c''$ is homeomorphic to $f=c$.

This proves the corresponding part of our statement, for otherwise there would exist such a sequence $a=c_0 < c_1 < c_2 < \ldots$ converging to c, $a < c \leqslant b$, that $f=c_i$ is homeomorphic to $f=c_k$, but not to $f=c$, for every i, k; as proved, however, there exists such a $c'' < c$ that $f=c''$ and $=c$ are homeomorphic; on the other hand, $f=c''$ is homeomorphic to every $f=c_i$; but all this contradicts our assumption.

To prove the corresponding part of Morse's theorem mentioned above we must construct a border and orthogonal trajectories $\{d\}$ from c'' to c', $c'' < c < c'$. The points on $f \leqslant c''$ are made to correspond to themselves. The point on $c'' \leqslant f \leqslant c$ lies on an orthogonal trajectory, or on a k-line, and divides the part of this trajectory, resp. the k-line, from c'' to c in a certain ratio l; the corresponding point will be that point of the same trajectory, resp. the k-line, which divides the part of the latter from c'' to c' in the same ratio l; $f \leqslant c$ is thus homeomorphically mapped on $f \leqslant c'$.

Proceeding to the critical point of index $k=1, 2, \ldots, n-1$, let us suppose that it is the origin and that it corresponds to the value of $f=0$. Let us choose the constants $e > \varepsilon > 0$ so small, that the border of the domain $-e^2 \leqslant f \leqslant e^2$ contains the parts of the trajectories $\{d\}$ from $-e^2$ to e^2, that there is no critical value of f other than zero in the closed interval $[-e^2, e^2]$ and that $E[f \leqslant e^2, p^2 = \varepsilon^2]$ ($E[\ldots]$ is the set of points satisfying he conditions contained in the brackets) belongs to

the neighbourhood of the origin which does not intersect the constructed border, and in which, in a definite system of co-ordinates, we have the representation: $f = -x_1^2 - \ldots - x_k^2 + x_{k+1}^2 + \ldots + x_n^2 = -p^2 + q^2$.

Let us consider the set $K = E[f = e^2] + E[f < e^2,\ p^2 = \varepsilon^2]$ and its subsets $K' = E[f = e^2,\ p^2 > \varepsilon^2] + E[f \leqslant e^2,\ p^2 = \varepsilon^2]$ and $K'' = E[f = e^2]$.

We obtain K' from K'' by operations which are performed within the considered neighbourhood and which leave the boundary unchanged. From the proof of Lemma 2 of the paper referred to below ([2]) we conclude that an orthogonal trajectory entering the domain between $f = -e^2$ and K' by crossing K' leaves this domain for the first time at a point of $f = -e^2$, if it does not meet a boundary point on its way. This condition will be satisfied for those trajectories which belong to the interior part of the domain; the exterior part, on the other hand, is covered by k-lines; this enables us to map topologically $f = -e^2$ on K' and $f \leqslant -e^2$ on $E[f \leqslant e^2,\ p^2 \geqslant \varepsilon^2]$ in the described way.

The second of these homeomorphisms extends the proof of the remaining part of Morse's theorem to general boundary conditions. The first reduces the question to a comparison of K' with K''.

We have

$$K = K' + E[f = e^2,\ p^2 < \varepsilon^2] = K'' + E[f < e^2,\ p^2 = \varepsilon^2].$$

$E[f = e^2,\ p^2 < \varepsilon^2]$ represents the topological product of the interior a_k of a $(k-1)$-sphere S_{k-1} into an $(n-k-1)$-sphere S_{n-k-1}: $(a_k S_{n-k-1})$; $E[f < e^2,\ p^2 = \varepsilon^2]$ — the product of a $(k-1)$-sphere S_{k-1} into the interior b_{n-k} of an $(n-k-1)$-sphere S_{n-k-1}: $(S_{k-1}\, b_{n-k})$; S_{k-1}, resp. S_{n-k-1}, are supposed to be divided into cells a_i, $i = 0, 1, \ldots, k-1$, resp. b_j, $j = 0, 1, \ldots, n-k-1$, in such a manner that there should be just two i-, resp. j-cells $(a_i', a_i''$, resp. $b_j' b_j'')$ and that both of them should be faces of an arbitrary cell of higher dimensionality. The possibility of such a representation may be inferred from ([3]), § 13–14.

Thus,

$$K = K' + (a_k b_j') + (a_k b_j''), \qquad j = 0, 1, \ldots, n-k-1;$$

$$K = K'' + (a_i' b_{n-k}) + (a_i'' b_{n-k}), \qquad i = 0, 1, \ldots, k-1.$$

Let us denote respectively by $\alpha_i, \alpha_i', \alpha_i''$ the numbers of i-cells, by H_i, H_i', H_i'' the matrices of incidence, by $\rho_i, \rho_i', \rho_i''$ the ranks mod. 2 of the latter and by $p^i, p_{\mathrm{I}}^i, p_{\mathrm{II}}^i$ the Betti numbers mod. 2 of the complexes K, K', K''.

H_{k+j}	$x \ldots x$	$(a_k b_j')$	$(a_k b_j'')$
y		0	0
.		.	.
.		.	.
.		.	.
y	H'_{k+j}	0	0
$(a_{k-1}' b_j')$		1	0
$(a_{k-1}'' b_j')$		1	0
$(a_{k-1}' b_j'')$		0	1
$(a_{k-1}'' b_j'')$		0	1
$(a_k b_{j-1}')$	0 . . . 0	1	1
$(a_k b_{j-1}'')$	0 . . . 0	1	1

K and K' do not differ from each other by cells of dimensions $\leqslant k-1$; consequently, $H_i \equiv H'_i$, $i=0,1,\ldots,k-1$.

For $i=k,\ k+1,\ \ldots,n-1$, for instance, for $i=k+j$, $j=0,1,\ldots,n-k-1$, the relation between H_{k+j} and H'_{k+j} is as follows (for $j=0$ the last two rows are to be omitted) (see the table).

By operations which do not affect the rank we can simplify this matrix as follows: for $j=0$ there will remain only one element different from zero in the last two columns, which will be situated in the third row from the end and in the last but one column; for $j=1,2,\ldots,n-k-1$ there will also remain only one element different from zero in the last two columns and rows, which will be situated at the intersection of the last but one column and row.

Hence we have:

$\alpha_i=\alpha'_i,\quad i=0,1,\ldots,k-1$ and $\alpha_i=\alpha'_i+2,\quad i=k,\ k+1,\ldots,n-1;$
$\rho_i=\rho'_i,\quad i=1,2,\ldots,k-1;$
$\rho_k=$either ρ'_k or $\rho'_k+1;$
$\rho_i=\rho'_i+1,\quad i=k+1,\ldots,n-1.$

In the same way:
$\alpha_i=\alpha''_i,\quad i=0,1,\ldots,n-k-1$ and $\alpha_i=\alpha''_i+2,\quad i=n-k,\ldots,n-1;$
$\rho_i=\rho''_i,\quad i=1,2,\ldots,n-k-1;$
$\rho_{n-k}=$either ρ''_{n-k} or $\rho''_{n-k}+1;$
$\rho_i=\rho''_i+1,\quad i=n-k+1,\ldots,n-1.$

A comparison of these two systems of relations will give the values of $\alpha''_i-\alpha'_i$ and $\rho''_i-\rho'_i$. The substitution of these values in the known formula $p^i=\alpha_i-\rho_i-\rho_{i+1}$ completes the proof.

The remaining cases $k=0$ and $k=n$ are similar. For $k=0$, for instance, the level surface $f=e^2$ for a sufficiently small positive constant e represents the sum of two separate point sets; the first consists of the points neighbouring the critical point and satisfying the relation $f=x_1^2+\ldots+x_n^2=e^2$, i. e. represents a $(n-1)$-sphere; the second is homeomorphic to $f=-e^2$, which can be proved by constructing the border of the domain $-e^2\leqslant f\leqslant e^2$ and by filling the interior part, except for the subtracted spheres (this subtraction, which takes place for each surface from 0 to e^2, does not affect the boundary), by orthogonal trajectories and the exterior part by k-lines. Thus, the $(n-1)$-sphere is the only component which distinguishes $f=b$ from $f=a$ topologically.

The author expresses his sincere gratitude to Prof. L. Lusternick for his directions during the preparation of the present paper.

Mathematical Institute.
State University.
Moscow.

Received
5. I. 1939.

REFERENCES

[1] Marston Morse, The Calculus of Variations in the Large. New York (1934). [2] Marston Morse a. George Booth Van Schaack, Annals of Math., **35**, 545—571 (1934). [3] Marston Morse, Trans. of the Amer. Math. Soc., **27**, 345—396 (1925).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

MATHÉMATIQUES

SUR LA LOI DE DISTRIBUTION DU COEFFICIENT DE CORRELATION DANS LES TIRAGES D'UN ENSEMBLE NORMAL

Par R. O. KUZMIN

(Présenté par S. N. Bernstein, de l'Académie, le 6. I. 1939)

§ 1. Deux quantités aléatoires x et y sont en correlation normale, si la probabilité p_s de ce qu'un point (x, y) appartienne au domaine S est exprimée par la formule:

$$p_s = \frac{1}{2\pi\sigma_x\sigma_y\sqrt{1-r^2}} \iint_S e^{-\frac{1}{2(1-r^2)}\left[\frac{(x-x_0)^2}{\sigma_x^2} - \frac{2r(x-x_0)(y-y_0)}{\sigma_x\sigma_y} + \frac{(y-y_0)^2}{\sigma_y^2}\right]} dxdy.$$

Les paramètres x_0, y_0, σ_x, σ_y et r sont exprimés de la manière suivante au moyen des espérances mathématiques des variables:

$$x_0 = Ex;\ y_0 = Ey;\ \sigma_x^2 = E(x-x_0)^2;\ \sigma_y^2 = E(y-y_0)^2;\ r\sigma_x\sigma_y = E(x-x_0)(y-y_0).$$

On peut dire que x_0 et y_0 sont les valeurs moyennes des variables x et y, σ_x et σ_y sont leurs standarts, r est le coefficient de correlation. D'ailleurs, on a toujours: $\sigma_x > 0$, $\sigma_y > 0$; $-1 < r < 1$. Ces notations sons empruntées au livre de V. Romanovsky (1). Le problème de la distribution des valeurs du coefficient empirique de correlation $\tilde{r}$ dans les tirages d'un ensemble à correlation normale présente une importance considérable. La loi différentielle de distribution dans le tirage à n objets est désignée dans la suite par $D_n(\tilde{r})$. Elle a été étudiée par R. A. Fischer (2) en 1915 et est exprimée par la formule

$$D_n(\tilde{r}) = \frac{(1-r^2)^{\frac{n-1}{2}}(1-\tilde{r}^2)^{\frac{n-4}{2}}}{\pi(n-3)!} \frac{d^{n-2}}{d\tau^{n-2}} \frac{\arccos(-\tau)}{\sqrt{1-\tau^2}}, \qquad (1)$$

dans laquelle on doit après avoir différentié poser: $\tau = r\tilde{r}$. Dans le volume suivant du même journal «Biometrica» K. Pearson et ses collaborateurs ont étudié dans un grand Mémoire les propriétés de la fonction $D_n(\tilde{r})$. Malheureusement, la méthode de ces auteurs conduit à un calcul compliqué. D'ailleurs, les auteurs n'ont pas réussi de donner la démonstration complète d'une propriété importante de la fonction $D_n(\tilde{r})$, d'après laquelle la loi de distribution de $D_n(\tilde{r})$ tend pour $n \to \infty$ et r fixé à la loi normale ayant pour moyenne r et pour dispersion $\frac{1-r^2}{\sqrt{n-1}}$. V. Romanovsky affirme qu'on n'a encore aucune démonstration suffisante de ce théorème.

Le but de ce travail est de combler cette lacune. Une de mes formules donne une simple voie pour étudier $D_n(\bar{r})$ assez facilement.

§ 2. Par une intégration immédiate on vérifie sans difficulté l'égalité suivante:

$$\frac{\arccos(-\tau)}{\sqrt{1-\tau^2}} = \int_1^\infty \frac{dx}{(x-\tau)\sqrt{x^2-1}}. \tag{2}$$

Il en suit facilement

$$\frac{d^{n-2}}{d\tau^{n-2}} \cdot \frac{\arccos(-\tau)}{\sqrt{1-\tau^2}} = (n-2)! \int_1^\infty \frac{dx}{(x-\tau)^{n-1}\sqrt{x^2-1}}. \tag{3}$$

En substituant dans (1) on a:

$$D_n(\bar{r}) = \frac{n-2}{\pi}(1-r^2)^{\frac{n-1}{2}}(1-\bar{r}^2)^{\frac{n-4}{2}} \int_1^\infty \frac{dx}{(x-\tau)^{n-1}\sqrt{x^2-1}}. \tag{4}$$

En désignant la dernière intégrale par I et en posant $x = \frac{1+\sigma\tau}{1-\sigma}$, nous obtenons:

$$I = \frac{1}{(1-\tau)^{n-\frac{3}{2}}\sqrt{2}} \int_0^1 \frac{(1-\sigma)^{n-2}\sigma^{-\frac{1}{2}}d\sigma}{\sqrt{1-\frac{1-\tau}{2}\sigma}} =$$

$$= \frac{1}{(1-\tau)^{n-\frac{3}{2}}\sqrt{2}} \left[\int_0^1 (1-\sigma)^{n-2}\sigma^{-\frac{1}{2}}d\sigma + 0(1)\int_0^1 (1-\sigma)^{n-2}\sigma^{\frac{1}{2}}d\sigma \right]. \tag{5}$$

Les intégrales obtenues sont des fonctions beta. En les exprimant par des gamma-fonctions et en se servant de la formule de Stirling, on a

$$I = \frac{1}{(1-\tau)^{n-\frac{3}{2}}} \left[\sqrt{\frac{\pi}{2n}} + 0\left(\frac{1}{n\sqrt{n}}\right) \right]. \tag{6}$$

De (4), (5) et (6) par un calcul simple nous obtenons:

$$D_n(\bar{r}) = \sqrt{\frac{n-1}{2\pi}} \left[\frac{(1-r^2)(1-\bar{r}^2)}{(1-r\bar{r})^2} \right]^{\frac{n-4}{2}} \frac{(1-r^2)^{\frac{3}{2}}}{(1-r\bar{r})^{\frac{5}{2}}} \left[1 + 0\left(\frac{1}{n}\right) \right]. \tag{7}$$

§ 3. De l'égaltité (7) il est facile d'obtenir la formule asymptotique pour $D_n(\bar{r})$. Introduisons dans ce but une variable nouvelle, en posant

$$\bar{r} = r + \frac{u}{\sqrt{n-1}}.$$

Cela étant, on obtient avec facilité les formules:

$$\frac{(1-r^2)^{\frac{3}{2}}}{(1-r\bar{r})^{\frac{5}{2}}} = \frac{1}{(1-r^2)} \left[1 + 0\left(\frac{u}{\sqrt{n}}\right) \right];$$

$$\frac{n-4}{2} \log \frac{(1-r^2)(1-\bar{r}^2)}{(1-r\bar{r})^2} = -\frac{u^2}{2(1-r^2)^2} + 0\left(\frac{u^2+u^3}{\sqrt{n}}\right). \tag{8}$$

Supposons à présent que $|u| < n^{\frac{1}{12}}$. Dans ce cas il suit de (8):

$$\left[\frac{(1-r^2)(1-\bar{r}^2)}{(1-r\bar{r})^2}\right]^{\frac{n-4}{2}} \frac{(1-r^2)^{\frac{3}{2}}}{(1-r\bar{r})^{\frac{5}{2}}} = \frac{1}{1-r^2} e^{-\frac{u^2}{2(1-r^2)^2}} \left[1+0\left(\frac{1}{n^{\frac{1}{4}}}\right)\right]. \quad (9)$$

On peut donc représenter (7) sous la forme:

$$D_n(\bar{r}) = \sqrt{\frac{n-1}{2\pi}} \frac{e^{-\frac{u^2}{2(1-r^2)^2}}}{1-r^2} \left[1+0\left(\frac{1}{n^{\frac{1}{4}}}\right)\right]. \quad (10)$$

Il en résulte que si $|u_1| < n^{\frac{1}{12}}$ et $|u_2| < n^{\frac{1}{12}}$, on a

$$\int_{\bar{r}_1}^{\bar{r}_2} D_n(\bar{r})\, d\bar{r} = \frac{1}{\sqrt{2\pi}(1-r^2)} \int_{u_1}^{u_2} e^{-\frac{u^2}{2(1-r^2)^2}}\, du + 0\left(\frac{1}{n^{\frac{1}{4}}}\right). \quad (11)$$

La valeur de l'intégrale du second membre, étendue à l'intervalle où $|u| > n^{\frac{1}{12}}$, est moindre que $n^{-\frac{1}{4}}$. Par conséquent on peut se débarrasser des conditions restrictives: $|u_1| < n^{\frac{1}{12}}$, $|u_2| < n^{\frac{1}{12}}$. La formule (11) est valable pour toutes les valeurs de u_1 et u_2. On peut représenter (11) sous la forme:

$$\int_{\bar{r}_1}^{\bar{r}_2} D_n(\bar{r})\, d\bar{r} = \frac{\sqrt{n-1}}{\sqrt{2\pi}(1-r^2)} \int_{\bar{r}_1}^{\bar{r}_2} e^{-\frac{(n-1)(\bar{r}-r)^2}{2(1-r^2)^2}}\, d\bar{r} + 0\left(\frac{1}{n^{\frac{1}{4}}}\right). \quad (12)$$

Ainsi le théorème indiqué est démontré.

§ 4. Pour obtenir une formule commode pour $D_n(\bar{r})$, il est utile d'introduire dans l'intégrale de l'égalité (4) une variable nouvelle, en posant: $x = \tau + (1-\tau)e^{\sigma}$. On obtient ainsi l'égalité:

$$\int_1^{\infty} \frac{dx}{(x-\tau)^{n-1}\sqrt{x^2-1}} = \frac{1}{(1-\tau)^{n-1}} \int_0^{\infty} e^{-(n-2)\sigma} \frac{1}{\sqrt{(e^{\sigma}-1)\left(e^{\sigma}+\frac{1+\tau}{1-\tau}\right)}}\, d\sigma. \quad (13)$$

Pour le deuxième facteur sous le signe d'intégrale dans le second membre il est facile de donner la formule:

$$\frac{1}{\sqrt{(e^{\sigma}-1)\left(e^{\sigma}+\frac{1+\tau}{1-\tau}\right)}} = \sigma^{-\frac{1}{2}} [A_0 + A_1\sigma + \ldots + A_{m-1}\sigma^{n-1} + O(1)\sigma^m]. \quad (14)$$

Ici $A_0, A_1, A_2, \ldots, A_{m-1}$ sont des polynômes en $\frac{1+\tau}{1-\tau}$ à coefficients rationnels. On peut obtenir sans difficulté les valeurs de ces derniers pour chaque m donné. On peut aussi donner une borne supérieure pour $O(1)$ — elle dépend de τ. En substituant (14) en (13) et en intégrant, on obtient:

$$\int_{\bar{r}}^{1} \frac{dx}{(x-\bar{r})^{n-1}\sqrt{x^2-1}} = \frac{\sqrt{\pi}}{(1-\bar{r})^{n-1}\sqrt{n-2}}\left[A_0 + \frac{1}{2}\frac{A_1}{n-2} + \cdots\right.$$

$$\left. \cdots + \frac{1.3\ldots(2m-3)}{2^{m-1}} \cdot \frac{A_{m-1}}{(n-2)^{m-1}} + R\right]. \qquad (15)$$

Ici on a:

$$R = O(1) \cdot \frac{1.3\ldots(2m-1)}{2^m} \cdot \frac{1}{(n-2)^m}.$$

En substituant dans (4) nous obtenons une formule commode pour étudier $D_n(\bar{r})$ pour les grandes valeurs de n pourvu que la quantité $(n-2)(1-\bar{r}\bar{r})$ soit aussi grande. Dans un autre recueil nous donnons une exposition plus détaillée de ce résultat et indiquons d'ailleurs quelques applications.

Manuscrit reçu
le 6. I. 1939.

LITTÉRATURE CITÉE

[1] В. Романовский, Матем. статистика (1938). [2] R. A. Fischer, Biometrica, **10**, 507 — 521 (1915).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

MATHÉMATIQUES

UNE FAMILLE DE CONGRUENCES À SURFACES DÉVELOPPABLES CORRESPONDANTES ET AUX POINTS FOCAUX SITUÉS SUR LES RAYONS CORRESPONDANTS DES DEUX CONGRUENCES

Par M. POTOTZKY

(Présenté par N. N. Lusin, de l'Académie, le 7.I.1939)

1. Considérons une configuration formée de deux congruences M_1M_2 M_3M_4 (congruences directrices) et d'une famille de congruences N_1N_2 dépendant d'un paramètre, où

$$N_1 = M_1 + \lambda(u, v)\, M_2; \quad N_2 = M_3 + \varphi(\lambda)\, M_4.$$

Les points N_1 et N_2 sont les points focaux des congruences de la famille N_1 N_2; les congruences de la famille elles-mêmes correspondent l'une à l'autre par leurs surfaces développables.

Appelons la famille des congruences N_1N_2 — famille H et étudions la configuration obtenue au moyen d'un tétraèdre mobile (1).

Nous prenons pour arêtes du tétraèdre mobile M_1M_2 et M_3M_4 — les rayons correspondants des deux congruences directrices, et M_1M_3 et M_2M_4 — rayons correspondants des deux congruences arbitraires de la famille H.

Les développements des dérivées des coordonnées des sommets du tétraèdre ont la forme

$$\begin{aligned} (M_i)_u &= \sum_{k=1}^{4} a_i^k M_k \\ (M_i)_v &= \sum_{k=1}^{4} b_i^k M_k \end{aligned} \qquad (i, k = 1 \ldots 4) \qquad (1)$$

où les a_i^k et b_i^k vérifient 16 conditions de compatibilité

$$(a_i^k)_v - (b_i^k)_u = \sum_j (b_i^j a_j^k - a_i^j b_j^k) \quad (j = 1 \ldots 4). \qquad (2)$$

En rapportant les congruences de la famille à leurs surfaces développables, nous trouvons pour le premier sommet du tétraèdre

$$M_{1u} = a_1^1 M_1 + a_1^3 M_3$$

et des égalités analogues pour les autres, ce qui donne

$$a_1^2 = a_1^4 = a_2^1 = a_2^3 = 0,$$
$$b_3^2 = b_3^4 = b_4^1 = b_4^3 = 0.$$

Les équations du problème seront

$$(N_1)_u = AN_1 + BN_2,$$
$$(N_2)_v = CN_1 + DN_2,$$

d'où, après avoir exclu les coefficients A, B, C, D et normé l'un des sommets, on a

$$\left.\begin{aligned} a_1^3 = a_2^4, \quad b_3^1 = b_4^2, \quad \varphi(\lambda) = \lambda, \\ \lambda_u = \lambda(a_1^1 - a_2^2), \\ \lambda_v = \lambda(b_3^3 - b_4^4). \end{aligned}\right\} \tag{3}$$

Les conditions de compatibilité pour λ donnent

$$(a_1^1 - a_2^2)_v = (b_3^3 - b_4^4)_u. \tag{4}$$

La configuration considérée définie par les équations (2), (3) et (4) dépend de deux fonctions arbitraires de deux arguments.

2. Une congruence arbitraire peut être inclue dans la famille H. Rapportons-la au tétraèdre de Wilczynski $P_1P_2P_3P_4$, caractérisé par le choix des sommets P_1 et P_3 aux points P_{2v} et P_{4u}.

Choisissons le tétraèdre $M_1M_2M_3M_4$ de telle manière que ses sommets M_2 et M_4 coïncident avec P_2 et P_4 et les deux autres soient définis par les formules

$$M_1 = A_1P_1 + A_2P_2 + A_3P_3 + A_4P_4,$$
$$M_3 = B_1P_1 + B_2P_2 + B_3P_3 + B_4P_4.$$

En exigeant que les rayons M_1P_2 et M_3P_4 soient les rayons correspondants des deux congruences directrices de la famille H, nous trouvons A_i et B_i $(i = 1, 3, 3, 4)$, ce qui est possible avec sept fonctions arbitraires d'un argument.

3. Les congruences directrices peuvent être paraboliques. En exigeant que les équations qui déterminent la position des points focaux des congruences directrices M_1M_2 et M_3M_4 aient une racine double, nous arrivons aux conditions:

$$(b_2^4 - b_1^2)^2 + 4b_2^3 b_1^4 = 0, \qquad (a_3^1 - a_4^2)^2 + 4a_3^2 a_4^1 = 0.$$

En les dérivant et en les ajoutant aux équations qui déterminent la configuration, nous voyons que notre affirmation est juste. On a d'ailleurs 15 fonctions arbitraires d'un argument. Si

$$b_2^4 - b_1^3 = 0, \quad b_1^4 = 0,$$
$$a_3^1 - a_4^2 = 0, \quad a_3^2 = 0,$$

on arrive au cas de deux congruences paraboliques directrices appartenant à un complexe linéaire spécial, ayant une surface focale commune dégénérée qui coïncide avec l'axe de ce complexe. Cette configuration dépend de deux fonctions arbitraires de deux arguments.

4. Une couple de congruences est dite stratifiable dans les deux directions, si chaque rayon de la première congruence coupe ∞^1 surfaces et les plans tangents à ces surfaces (menés aux points d'intersection avec le rayon) passent par le rayon correspondant de la seconde congruence, et réciproquement.

En stratifiant les congruences directrices au moyen de surfaces focales de la famille H, nous obtenons les conditions:

$$b_2^1 = b_1^2 = a_4^3 = a_3^4 = 0, \qquad a_1^1 - a_2^2 = a_3^3 - a_4^4, \qquad b_1^1 - b_2^2 = b_3^3 - b_4^4;$$

et d'ailleurs une couple quelconque de congruences de la famille H se trouve en correspondance T [1], et les congruences de la famille appartiennent à des complexes linéaires.

Inversement: Si une couple quelconque de congruences de la famille H (par exemple, M_1M_3 et M_2M_4) est en correspondance T, une couple arbitraire de congruences de cette famille est en correspondance T et les congruences directrices sont stratifiées par les surfaces de la famille.

5. La configuration de Jonas [1] est formée de quatre congruences dont deux M_1M_3 et M_2M_4 sont des congruences R et correspondent l'une à l'autre par les surfaces développables, tandis que les deux autres M_1M_2 et M_3M_4 sont des congruences W.

En faisant les congruences R inclues dans la famille H, nous trouvons que les surfaces focales des congruences M_1M_3 et M_2M_4, c'est-à-dire M_1 et M_3 et respectivement M_2 et M_4, sont rectilignes, et d'ailleurs chaque couple M_1 et M_2, M_3 et M_4 représente une même surface rectiligne; les rayons des congruences de la famille H sont leurs tangentes communes.

6. Les rayons des congruences de la famille H qui coupent deux rayons correspondants des deux congruences directrices représentent une famille de génératrices d'une surface du second ordre passant par les rayons correspondants des congruences directrices. Cette surface du second ordre est tangente aux deux congruences directrices le long de ces rayons.

Au moyen d'une famille de ∞^2 de telles surfaces on obtient une transformation de l'une de ces congruences en l'autre — problème qui a été posé par M. S. Finikoff.

7. Le cas d'intersection des rayons correspondants des congruences directrices M_1M_2 et M_2M_3 est caractérisé par les égalités:

$$a_1^4 = a_2^4 = 0, \quad b_2^4 = b_3^4 = 0, \quad a_1^3 = b_3^1 = 0.$$

La configuration dépend de trois fonctions arbitraires de deux arguments. Si l'on a d'ailleurs l'égalité $a_2^1 = b_2^3 = 0$, alors la suite (M_1M_2)—(M_2M_3) est la suite de Laplace, et la congruence de la famille N_1N_2, où

$$N_1 = M_1 + \lambda M_2, \quad N_2 = M_3 + \varphi(\lambda) M_2,$$

appartient à la suite inscrite de Laplace. Le paramètre λ est défini par une équation aux dérivées partielles du second ordre. La configuration dépend de deux fonctions arbitraires de deux arguments.

Les rayons correspondants des deux congruences directrices (dans le cas de leur intersection) ne peuvent être tangents aux lignes asymptotiques sur leur surface commune (M_2) sans que cette surface (M_2) dégénère en un plan. Donc, les congruences directrices ne peuvent pas être paraboliques.

8. Une configuration formée d'une famille de congruences paraboliques dont les surfaces développables sont correspondantes et dont les points focaux se trouvent sur les rayons de la seule congruence directrice dépend de 4 fonctions arbitraires de deux paramètres.

Deux paramètres, définissant la position d'un rayon d'une congruence de la famille, sont définis par un système de deux équations aux dérivées partielles du premier ordre.

Institut Mathématique.
Université de Moscou.

Manuscrit reçu
le 8.I.1939.

LITTÉRATURE CITÉE

[1] S. Finikoff, Géométrie projective-différentielle (en russe), Moscou (1937); Annali di Pisa, 2,2 (1933).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

MATHÉMATIQUES

UNE REMARQUE SUR LE THÉORÈME DE D. TH. EGOROFF

Par G. TOLSTOFF

(Présenté par I. M. Vinogradow, de l'Académie, le 17. XII. 1938)

Le théorème de D. Th. Egoroff s'énonce de la manière suivante:

Si une seule des fonctions mesurables converge sur un ensemble borné et mesurable E, il existe un ensemble $\mathfrak{s}$ de mesure aussi proche que l'on veut de celle de E et tel que la convergence sur $\mathfrak{s}$ est uniforme.

Considérons au lieu d'une suite de fonctions $f_n(x)$, $(n=1,2,3,\ldots)$, une certaine fonction $f(x,y)$ de la variable x et du paramètre y. On peut se poser la question si le théorème de D. Egoroff reste valable quand on sait que pour tous les x d'un certain ensemble mesurable E on a $\lim\limits_{y\to 0} f(x,y)=f(x)$. Autrement dit, peut on, quel que soit $\omega>0$, trouver un ensemble mesurable $\mathfrak{s}$, $\mathfrak{s}\subset E$, tel que mes $\mathfrak{s}>$ mes $E-\omega$ et que la fonction $f(x,y)$ pour tous les x appartenant à $\mathfrak{s}$ tend uniformément par rapport à x vers $f(x)$ quand $y\to 0$? Si l'on exige la mesurabilité de $f(x,y)$ (au sens de M. Lebesgue) par rapport à l'ensemble des variables x et y, ou bien si l'on exige encore que $f(x,y)$ soit mesurable par rapport à la première des variables quand la seconde a une valeur fixe et réciproquement, on peut à l'aide de l'axiome de M. Zermelo construire sans difficulté une fonction $f(x,y)$ pour laquelle la question précédemment posée se résout par la négative. En effet, soit $E_1, E_2, \ldots, E_n\ldots$ un système d'ensembles jouissant des propriétés suivantes:

$$\mathrm{mes}_e\, E_n=1 \quad (n=1,2,3,\ldots)$$

$$\sum_{n=1}^{\infty} E_n=[0,1].$$

À l'aide de l'axiome de M. Zermelo il est facile de construire des ensembles de cette nature *. Nous les supposerons situés sur l'axe OX.

Soient ε_n $(n=1,2,3,\ldots)$ des nombres positifs tendant vers zéro pour $n\to\infty$. Si les coordonnées d'un point dans le carré unitaire du plan XOY ont la forme $(x_0\, \varepsilon_n x)$, où $x\subset E_n\,(n=1,2,3,\ldots)$, nous poserons $f(x,y)=1$. En tous les autres points de ce carré nous posons $f(x,y)=0$. Il est évident que pour chaque point x, $0<x<1$, on a

$$\lim_{y\to 0} f(x,y)=0.$$

* Voir, par exemple, N. Lusin, Sur la structure des fonctions mesurables (Note III à l'édition russe du livre de M. Lebesgue «Sur l'intégration et les recherches des fonctions primitives», Moscou, 1934).

D'autre part, il est évident que la convergence ne peut être uniforme sur aucun ensemble de mesure positive.

La fonction construite est nulle partout dans le carré unitaire, sauf aux points d'un ensemble situé sur une infinité dénombrable de droites. Donc, elle est mesurable au sens de M. Lebesgue par rapport à l'ensemble des variables x et y. Pour chaque valeur fixée de y, la fonction $f(x, y)$ n'admet qu'un nombre fini de points de discontinuité par rapport à x, donc, elle est mesurable comme fonction de x. On obtient la même conclusion en considérant $f(x, y)$ pour une valeur fixée de x.

On obtient une autre réponse à la question posée, si l'on exige que $f(x, y)$ soit mesurable B.

Nous allons démontrer le théorème suivant:

Si $f(x, y)$ est défini sur un ensemble mesurable B, est mesurable B sur cet ensemble par rapport à l'ensemble des variables x et y, si, d'ailleurs, pour tous les points d'un ensemble E borné et mesurable (en général au sens de M. Lebesgue) on a $\lim_{y \to 0} f(x, y) = f(x)$, *alors il existe un ensemble mesurable* $\mathfrak{s}$ *dont la mesure est aussi proche que l'on veut de celle de E et telle que la convergence $f(x, y) \to f(x)$ est uniforme par rapport à x sur* $\mathfrak{s}$.

Il est facile à voir que l'ensemble E et la fonction $f(x)$ peuvent être supposés mesurables B, car dans le cas contraire il suffirait de considérer au lieu de E un ensemble mesurable B de mesure égale à celle de E et sur lequel $f(x)$ est mesurable B.

Démonstration. Soit $\omega > 0$ aussi petit que l'on veut. Pour chaque $x \subset E$ il existe un nombre positif $\delta'_n(x)$ tel que

$$|f(x, y) - f(x)| < \frac{1}{n},$$

pourvu que $|y| < \delta'_n(x)$.

Posons $\delta_n(x) = \sup \delta'_n(x)$ pour n et x fixes. Montrons que $\delta_n(x)$ est mesurable au sens de M. Lebesgue. En effet, considérons l'ensemble $E[x, \delta_n(x) < A]$. Si x appartient à cet ensemble, cela signifie qu'il existe une valeur de y, $0 < y < A$, pour laquelle $|f(x, y) - f(x)| \geqslant \frac{1}{n}$. Inversement, s'il existe un y, $0 < y < A$, pour lequel on a $|f(x, y) - f(x)| \geqslant \frac{1}{n}$, on a évidemment $x \subset E[x, \delta_n(x) < A]$. On en déduit que l'ensemble $E[x, \delta_n(x) < A]$ est la projection sur l'axe OX de la partie de l'ensemble $E\left[(x, y), |f(x, y) - f(x)| \geqslant \frac{1}{n}\right]$, contenue dans la bande $0 < y < A$. Mais la fonction $|f(x, y) - f(x)|$ est mesurable B. Donc,

$$E\left[(x, y), |f(x, y) - f(x)| \geqslant \frac{1}{n}\right]$$

est un ensemble mesurable B. Ls projection d'un ensemble mesurable B est toujours un ensemble A, donc, il est mesurable au sens de M. Lebesgue. Il en résulte que $\delta_n(x)$ est mesurable au sens de M. Lebesgue. On a partout sur E: $\delta_n(x) > 0$. Il existe donc un ensemble E_n, $E_n \subset E$, mes E — mes $E_n < \frac{\omega}{2^n}$, sur lequel $\delta_n(x) \geqslant \delta_n$, où δ_n est une certaine constante positive.

Posons

$$\mathfrak{s} = \prod_{n=1}^{\infty} E_n$$

$$\text{mes } (E - \mathfrak{s}) = \text{mes} \sum_{n=1}^{\infty} (E - E_n) \leqslant \sum_{n=1}^{\infty} \text{mes } (E - E_n) =$$

$$= \sum_{n=1}^{\infty} (\text{mes } E - \text{mes } E_n) < \omega.$$

Donc, la mesure de $\mathfrak{s}$ ne diffère de celle de E que de ω au plus. D'autre part, $f(x, y)$ tend uniformément vers $f(x)$ sur $\mathfrak{s}$. En effet, si $\alpha > 0$ est donné, on peut choisir n assez grand pour que l'on ait: $0 < \frac{1}{n} < \alpha$; alors pour tous les $x \subset \mathfrak{s} \subset E_n$ nous aurons

$$|f(x, y) - f(x)| < \frac{1}{n} < \alpha,$$

pourvu que $|y| < \delta_n$. Le théorème est donc démontré.

Remarquons que dans ce théorème on aurait pu supposer que y, au lieu de tendre vers zéro, tend vers une valeur $\varphi(x)$, où $\varphi(x)$ est une fonction quelconque mesurable au sens de Lebesgue. Le théorème reste valable.

Manuscrit reçu
le 5. I. 1939.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

PHYSICS

ON NON-IONIZING PARTICLES IN THE PENETRATING COMPONENT OF COSMIC RADIATION

By V. I. VEKSLER

(Communicated by S. I. Wawilow, Member of the Academy, 27.XII.1938)

In a communication made by the author(1) on the 1st of October, 1938, at the Symposium on the Atomic Nucleus held under the auspices of the Academy of Sciences in Leningrad, he advanced the supposition that non-ionizing particles are to be found in the penetrating component of cosmic radiation. Mention was made of the fact that numerous inferences relating to the existence of such particles could be drawn both from the results of the author's own experiments and from a number of facts referring to the second maximum of Rossi's curve.

The object of the present paper consists in a somewhat more detailed discussion of the hypothesis of non-ionizing particles.

Analysis of Rossi's Shower Curves. Ackeman (3), Drigo(4) and especially Bothe and Smeiser (5), while working with different material, found that at thicknesses corresponding to 200 g/cm² a second maximum of Rossi's curve is to be observed.

Bothe and Smeiser, who investigated the properties of particles corresponding to the second maximum, consider them to be secondary heavy electrons formed by the hard component. According to Smeiser(6), more than 80% of these particles have free paths, which do not exceed 100—110 g/cm². However, according to the data of these authors, the second maximum of Rossi's curve corresponds to a thickness of the order of 180—200 g/cm². If this situation had been determined by the maximum paths of the particles, as established, say, in the above quoted work of Smeiser, then, within the range from 110 to 180—200 g/cm², the number of showers should have increased no more than 18 to 20%. At the same time in reality it increases within the stated limits about 50%. The surmise that the showers in the second maximum are set up directly by the ionizing penetrating particles themselves is also at variance with the following: according to Bothe and Smeiser's data, after a thickness of the order of 180 g/cm², corresponding to the maximum, the number of these showers falls off at a much quicker rate than the intensity of the ionizing penetrant, with which they should have been in equilibrium if they had really been set up by it.

Thus, the very availability of a quick downfall of showers after the maximum is reached goes a long way towards proving the existence of some kind of intermediate particles, which are responsible for Bothe and Smeiser's showers.

Making good use of the data of these authors on the distribution of particles by their free paths, it is possible to derive the conclusion that the path of the main group of shower particles of the second maximum exceeds 60—70 g/cm². Coupled with the fact that the absorption curve of cosmic radiation determined by Auger-Rossi's method in the region of 200 g/cm² runs altogether smoothly and has no hump, this again calls for the admission of a non-ionizing component.

Absorption Curves of Cosmic Radiation. Kulenkampf ([7]), Clay([8]), Ehmert([9]), Sittkus([10]) and especially Maass([11]) have investigated the effect of secondary radiation upon the absorption curve of cosmic radiation. According to these authors, the placing of dense material above vertically installed counters (Fig. 1, *a*) appreciably increases the number of coincidences in comparison with the case when the filter is placed between the counters (Fig. 1, *b*).

According to Maass, this difference increases with increase in the bulk of the iron filter and with a thickness of the order of 200 g/cm² it gives per unit of time 20% of the total amount of coincidences corresponding to position *b*. Making use of the numerical data of Sittkus, who investigated the secondary radiation of lead, it is possible to evaluate the additional number of coincidences, caused in the experiments of the above-named author by placing lead over the counters, at 30%. It is natural to explain the difference in the amount of coincidences corresponding to these two different positions of the filter by the presence of non-ionizing radiation. (This was, in particular, done by Maass who erroneously identified this non-ionizing radiation with ultra γ-rays). However, such an explanation could not claim a title of being the only one. Indeed, it is clear that if the filter be placed above the counters in position *a*, a much greater number of penetrating ionizing particles will be fixed owing to the secondaries which will be liable to set up these particles in lead. Thus, although the ionizing particles themselves will not pass through the counters, the secondary particles created by the ionizing ones may do so. This might, it was said, account for the increase observed under experimental conditions. However, after the experimental work of Bothe and Smeiser, this objection may appear of little consequence. Indeed, the research of these authors has shown that particles with a very great penetrating power are concentrated in a very small bodily angle. Hence it follows that the difference in the number of coincidences in cases *a* and *b* can by no means be explained by the different number of ionizing particles, not fixed in the second case and fixed in the first one thanks to the secondary ones.

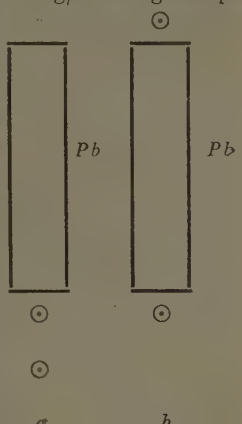


Fig. 1.

This difference cannot be explained by the scattering of penetrating particles, as on the absorption curve corresponding to case *a* there will be observed a hump, which is absent on curve *b*. The position of this hump both in iron (Maass) and in lead (Clay) agrees well with the position of the shower maxima of Bothe and Smeiser. Thus, if we are to confront the data of Ackeman, Bothe and Smeiser with the experimental evidence of Kulenkampf, Sittkus, Maass, Clay and others, we shall readily find that secondary shower-radiation measured in the second maximum by Rossi's curve is the immediate reason for the difference in the run of Maass' absorption curves.

However, from the above-mentioned it follows with certainty that this difference can be determined only by non-ionizing radiation. Thus, it follows

directly from the absorption curves that showers in the second maximum are set up by non-ionizing radiation. which fact agrees well with the results of our experiments.

The above-mentioned shows that a clear understanding of the sum total of the experimental evidence adduced is impossible without admitting the existence of a non-ionizing component forming part of penetrating radiation.

The considerations given below prove the erroneousness of the supposition to the effect that the non-ionizing component should consist of high energy photons*.

1. The growth of the number of heavy ionizing particles with increase of the lead thickness to 200 g/cm^2, disclosed by Veksler and Dobrotin ([2]), should be referred to the data by Bothe and Smeiser, according to which the second maximum of the Rossi's curve is conditioned by the action of the hard component. At the same time photons enter the composition of the soft component of cosmic radiation. Consequently, the particles observed in the above quoted work([1]) cannot be set up by photons.

2. Bothe and Smeiser have shown that, both in iron and in lead, the maximum of showers corresponds to a thickness of about 200g/cm^2. However, if it were photons that could be held responsible for these showers, the position of the maximum in iron would be likely to be shifted towards a thickness of about 400 g/cm^2, this being in accordance with the relationship of masses of l units for iron and lead.

3. In contradistinction to the opinions advanced in the preceding, Heitler([12]), taking his starting point in Yukava's theory, found that the heavy electrons constituting the penetrating component are formed at a height of 10 cm Hg by photons with an energy approximating 10^8—$5 \cdot 10^8$ eV. It is, however, easy to show that the particular magnitude of effective section, which Heitler obtained for the processes of heavy electrons being set up by photons, fails to agree with experimental evidence.

a) According to the cascade theory of showers, at any appreciable distance from the top of the atmosphere the primary particles have already started prolification. Therefore, the number of quanta with an energy close to 10^8, i. e. critical one, should be proportional to the full number of electrons (+ and —) at the given altitude.

It stands, however, to reason that in this case the latitudinal effect for the penetrating component at sea level would be as great as the latitudinal effect for electrons at great heights, which is not to be observed under actual conditions.

b) The calculation of the intensity of the penetrating component at sea level conducted by Heitler in confirmation of the correctness of his calculation is, as a matter of fact, based on a mistake**. Therefore comparisons of theoretical results with experimental evidence should be effected at a height of 36 cm and less, which elevation can still be reached by the heavy electrons with an energy of $5 \cdot 10^8$ set up by photons at an altitude of 10 cm Hg.

The full intensity of penetrating radiation should, at this height, be composed of two parts. The first are those particles which possess an energy suf-

---

* Great energies are required in order to explain the existence of showers and the availability of particles with great penetrating power in the second maximum.

** Processes of creation of heavy electrons with a maximum energy of $5 \cdot 10^9$ eV are considered. The fact stands, however, that not a single particle formed by photons of such energy at a height of 10 cm Hg will ever be able to reach the surface of the earth, as the loss of its energy on ionization alone is equal to $1.3 \cdot 10^9$ eV, i. e. it will be almost three times the full energy of the photon.

ficient for reaching the surface of the earth (taking into account only ionization losses). The full number of such particles can be found by extrapolating the intensity of cosmic radiation at sea level to a height of 36 cm Hg. Besides this, beginning approximately from this height, those particles which are formed by photons in processes described by Heitler should also be added on. Consequently, we are entitled to expect a sharp growth in the intensity of penetrating radiation beginning from a height of about 36 cm.

It has, however, been found experimentally that the rigid component grows with the same coefficient till absorption beginning from sea level and up to great altitudes.

Thus, it is found that Heitler's calculation fails to agree with theory.

From the above-mentioned it will be clear that non-ionizing particles, responsible for the formation of secondary heavy electrons and also for the appearance of a second maximum in Rossi's curve, a r e n o t p h o t o n s. It is possible that they are neutrinos with high energy, which, according to Euler[13] and Haisenberg, are apt to be set up in course of the spontaneous disintegration of heavy electrons. Lastly, it is possible that these are new particles, so-called «neutrettos», whose existence was assumed by Heitler on the basis of theoretical calculations relating to nuclear forces.

Our available experimental material does not, however, permit us to say which of these hypotheses is the right one.

After this article had already been written, we received the December issue of Science. The short communication published in it regarding Schonn's work confirms our arguments, previously stated elsewhere and discussed in detail in this paper, to the effect that there exist neutral particles in cosmic radiation.

Received
27. XII. 1938.

REFERENCES

[1] V e k s l e r, C. R. Acad. Sci. URSS, XXI, № 3 (1938). [2] V e k s l e r a. D o b r o t i n, C. R. Acad. Sci. URSS, XIX, 479 (1938). [3] A c k e m a n, ZS. f. Phys., **94**, 303 (1935). [4] D r i g o, La Ricerca Scientifica, VII, 88 (1934). [5] B o t h e u. S m e i s e r,, Ann. d. Phys., **32**, H. 1—2 (1938). [6] S m e i s e r, ZS. f. Phys., **110**, 443 (1938). [7] K u l e n k a m p f, Phys. Zeit., **35**, 996 (1934). [8] C l a y, Physica, VIII, № 5 (1936); VII, 627 (1936). [9] E h m e r t, ZS. f. Phys., **106**, 751 (1937). [10] S i t t k u s, ZS. f. Phys., **108**, 420 (1938). [11] M a a s s, Ann. d. Phys., **27** (5), 507 (1936). [12] H e i t l e r. Proceed. of Roy. Soc., **166**, 529 (1938). [13] E u l e r, ZS. f. Phys., **110**, 692 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

PHYSICS

GAMMA-RAYS FROM RADIOACTIVE IODINE (I^{128})

By M. A. BAK and N. N. NIKOLAEVSKAYA

(Communicated by A. F. Joffe, Member of the Academy, 3. I. 1939)

Gamma-radiation of radioactive iodine (I^{128}), prepared by bombarding the iodine with slow neutrons, was investigated.

There is disagreement on this point in previous works. The presence of gamma-rays in I^{128} has been qualitatively demonstrated by Amaldi (1), while the results obtained by A. Roberts and J. W. Irvine (2) were negative. These authors disposed of a source of I^{128}, emitting 10^5 electrons per minute, which should be evidently referred to the beginning of measurements. They used a neutron source with 150 mC radon and beryllium. The experimental conditions of this work lead the authors to an assumption that if gamma-rays were present in I^{128}, their energy would not exceed 0.5 MeV, while the relation of gamma-quanta to the number of beta-rays would by no means surpass 0.1.

It stands to reason that in this way we obtain no solution, be it a merely qualitative one, of the problem as to the presence of gamma-rays in the radioactive iodine. The increasing of the source activity will make it possible to prove whether beta-disintegration of iodine is accompanied by the emission of gamma-rays.

In our measurements the activity of the source of I^{128} was from 0.5 to $1.0 \cdot 10^5$ electrons per second ($3—6 \cdot 10^6$ electrons per minute) to the beginning of measurements. Radioactive iodine has been prepared by bombarding ethyliodide (C_2H_5I) with slow neutrons. As a source of neutrons served beryllium, gamma-rayed from a tube of the Lange-Brasch type, fed by impulse tension. The radioactive iodine was separated from ethyliodide by the method of chemical extraction with subsequent filtration. Radioactive iodine was precipitated on a filter with an area of 20 cm^2 in the form of silver iodine. Detection of gamma-radiation and energy determination were effected by measuring the curve of absorption in the substance.

For measurements we had recourse to an ordinary Geiger-Müller counter of gamma-rays.

Preliminary measurements have shown the presence of gamma-rays. This radiation might, however, be due to «bremsstrahlung» of comparatively large number of beta-rays with energies up to 2.1 MeV stopped in the filter (beta-spectrum of iodine). To find out the rôle of «bremsstrahlung», experiments were carried out throwing light upon the dependence of the gamma-radiation observed on the atomic number of the substance in which stopping power is observed. Those substances proved to possess sharply differing atomic numbers, the intensity of «bremsstrahlung» in the first approxima-

tion being proportional to z. Moreover, theoretical calculations of the «bremsstrahlung» spectrum were effected.

From Bethe and Heitler's[3] formula for electron radiation generalized by us for the case of a thick anticathode and of a beta-spectrum of a definite shape (see below), one may determine the presumed number of gamma-quanta of «bremsstrahlung» in elements with different z. Table 1 gives computed values for the relation of the number of gamma-quanta of «bremsstrahlung» to the number of electrons, stopped in lead. A regular and linear slope of the beta-

Table 1

Form of electron spectrum	Number of gamma-quanta of «bremsstrahlung» per one electron for lead			
	Gamma-quanta with energy 50—2100 kV	Gamma-quanta with energy 100—2100 kV	Gamma-quanta with energy 200—2100 kV	Gamma-quanta with energy 500—2100 kV
Regular	0.15	0.09	0.05	0.015
Linear slope	0.08	0.05	0.02	0.007

spectrum has been selected. The actual electron energy distribution in the iodine spectrum is by far more complex than that adopted, yet, the effect of «bremsstrahlung» will be expressed by intermediate values. From Table 1 it may be seen that the intensity of «bremsstrahlung» per one electron is too small even for lead. This table may readily be recalculated for the case of aluminium.

Thus, all the intensity values of «bremsstrahlung», calculated in Table 1 for lead, should be reduced 6.3 times when recalculated for aluminium. The presence of gamma-rays from I^{128} would still more reduce this ratio. If the radioactive iodine's own gamma-radiation prevails, then the effect of «bremsstrahlung» may prove within the experimental error. Besides, the presence of sufficiently thick walls of the gamma-quanta counter, absorbing an appreciable part of the soft component of «bremsstrahlung», would still more reduce the portion of «bremsstrahlung» recorded.

Table 2

Filter	Number of supplementary impulses per one minute, referred to the first minute
Aluminium—lead	160±5
Lead—aluminium	151±5

To solve the question as to the rôle of «bremsstrahlung», and to prove that radioactive iodine is emitting gamma-rays, the following experiment was carried out: two screens, an aluminium and a lead one, put together, were placed between the source of I^{128} and the gamma-quanta counter, at first with their aluminium and next with the lead-side turned to the iodine. This permitted of detecting the rôle of the «bremsstrahlung», the rays emitted by the iodine itself suffering similar absorption. Each separate screen was absorbing the main mass of electrons (the aluminium plate was 3.25 mm thick, and the lead one 1.4 mm thick).

The results of these measurements are given in Table 2.

Table 2 gives the number of additional impulses recorded by the counter, calculated for one minute and referred to the first minute following the end

of the bombardment of iodine with neutrons. A series of experiments have shown that the total number of additional impulses recorded by the counter, referring to each of the filter-combinations, was 600.

The data obtained are identical within experimental error. Consequently, the share of the «bremsstrahlung» is immaterial, the effect being chiefly due to gamma-rays emitted by I^{128} itself. The thickness of the stopping-layer (lead —1.4 mm, or aluminium—3.25 mm) and the walls of the counter (lead—1 mm) are absorbing the main portion of the «bremsstrahlung», thus reducing the effect to 2—3% of the total gamma-radiation.

Further on the energy of gamma-radiation emitted by I^{128} was determined. There was taken the absorption curve for lead. Lead filters were chosen in the shape of cylinders whose thickness varied from 2 mm to 7 mm (as well

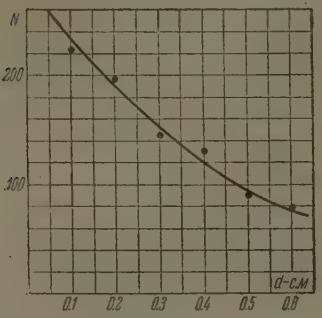


Fig. 1.

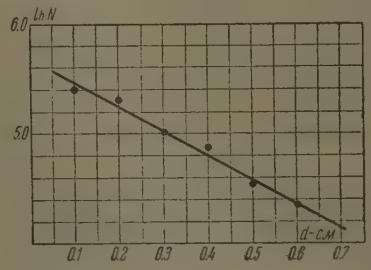


Fig. 2.

as the thickness of the counter's walls). Measurements were effected beginning with larger thickness and passing to smaller ones, and lasted 5 minutes for each thickness. Experimental conditions thus chosen gave a rather similar total number of additional impulses recorded by the counter for each filter thickness. This permits of considering the statistical significance of the measurements equal, and the counters' efficiency as being constant.

In all six independent experiments were carried out, each of them involving measurements of the entire curve of absorption. The total number of additional impulses per each thickness of the absorbing layer of lead was of the order of 1000—1200. The number of gamma-quanta recorded by the counter during all the measurements was 30—40 additional impulses per minute, the background being 15 impulses per minute.

The results of the measurements of absorption of gamma-rays emitted by I^{128} are graphically represented in Fig. 1, where is given the dependence of the number of additional impulses recorded by the counter, recalculated per one minute and referred to first minute following the close of irradiation, upon the thickness of the lead screen. Curve 2 gives the dependence of the logarithm of intensity of gamma-radiation upon the thickness of the lead screen. The experimental points do fairly well fit within the straight line (Fig. 2).

The coefficient of absorption in lead derived herefrom proves equal to $\mu \approx 2.2$ cm^{-1}, the value for the absorption coefficient per one electron thus being $\mu_e \approx 8.1 \cdot 10^{-25}$. Such an absorption coefficient corresponds to a gamma-ray energy value $\approx$400—500 kV ([4]).

The data obtained permit of determining the number of gamma-quanta corresponding to one beta-particle emitted. The efficiency of the counter for gamma-rays may be considered equal to 0.004—0.003 for energies of the order of 0.5 MeV ([3]). Hence it follows that the ratio of gamma-quanta to beta-rays is 1 : 2 or 3.

Conclusions

1. Beta-disintegration of radioactive iodine induced by bombardment of iodine with slow neutrons was found to be accompanied by emission of gamma-rays.

2. The energy of quanta emitted ≈ 0.4—0.5 MeV.

3. The relation of the number of gamma-quanta per one beta-particle was determined as equal to $^1/_2$—$^1/_3$.

4. The gamma-line found may be used to determine the absorption coefficient of rays of a given hardness in different metals.

Received
3. I. 1939.

REFERENCES

[1] E. Amaldi, Phys. ZS., **18**, 692 (1937). [2] A. Roberts a. J. W. Irvine, Phys. Rev., **53**, 609 (1938). [3] Bethe a. Heitler, Proc. Roy. Soc., **146**, 83 (1934). [4] W. Gentner, Phys. ZS., **21**, 836 (1937). [5] G. v. Droste, ZS. f. Phys., **100**, 529 (1936).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

GEOPHYSICS

ON THE RADIATIVE EQUILIBRIUM OF THE EARTH ATMOSPHERE

By A. I. LEBEDINSKY

(Communicated by V. G. Fessenkov, Member of the Academy, 4. I. 1939)

The absorption of the infra-red radiation in the lower layers of the earth atmosphere is chiefly stimulated by water vapours contained in the air, and can thus be considered as approximately proportional to their density. The dependence of the temperature of the air and the density of the water vapour upon the height being known, it becomes possible to calculate the value of the flux of the infra-red radiation for any small interval of frequencies without introducing the assumption as regards the independence of the coefficient of absorption of the length of the wave.

The intensity of the upward radiation with the range of frequencies from ν_1 to ν_2 can be represented by the following formula:

$$I'(x) = B + (B_e - B_1)\, A\,[mp\,(1-x)] + \int_x^1 \frac{dB}{d\xi} A\,[mp\,(\xi - x)]\, d\xi \qquad (1)$$

and the intensity of the downward radiation, by the formula

$$I''(x) = B - B_0 A\,[mpx] - \int_0^x \frac{dB}{d\xi} A\,[mp\,(x-\xi)]\, d\xi. \qquad (2)$$

The general flux with the range of frequencies from ν_1 to ν_2 will be equal to the difference $I' - I''$. In formulae (1) and (2) the following expression is assumed as the independent variable

$$x = \frac{1}{m}\int_z^\infty \rho_w\, dz,$$

where

$$m = \int_0^\infty \rho_w\, dz,$$

ρ_w—density of the water vapour, and z—altitude above the earth surface. B— intensity of radiation of the black body with the range of frequencies from ν_1 to ν_2:

$$B = \frac{2h}{c^2}\int_{\nu_1}^{\nu_2} \nu^3 \left[e^{\frac{h\nu}{kT}} - 1\right]^{-1} d\nu.$$

B_e, B_1 and B_0 are values of B under different temperatures which correspond to those of the earth surface, of the air layers neighbouring this surface and the external boundary of the earth atmosphere respectively.

p is an abstract number; $p=2$ in the case when the equations of the radiative equilibrium for the monochromatic radiation are solved according to Schwarzschild's approximation. In the case, however, when the solution corresponds to Eddington's approximation, $p=1.5$.

The function $A[t]$ is equal to that part of radiation with the range of frequencies from ν_1 to ν_2 which is passing through a layer of water vapour (the thickness of the latter being t) without being absorbed. This function can be considered as a known one owing to the measurements of the transparence of water vapour carried out by Fowle and Falckenberg. Assuming that

$$A[t]=c\lg\frac{a+t}{b+t},$$

where

$$a>b, \qquad c=\frac{1}{\lg\frac{a}{b}},$$

it becomes possible to approximate numerical values obtained by these authors to an exactitude of 1%. The substitution of the value $A[t]$ performed in (1) and (2), and the utilization of the value of the air temperature and of that of the density of water vapour, these values being obtained from direct measurements, make it possible to find out I' and I'' by means of numerical integration. The calculations become highly simplified, if one can assume that the density of water vapour varies with the height according to the exponential law, and that B is constant in the stratosphere and can be represented by a linear function of the altitude z in the troposphere. In this case I' and I'' can be expressed in elementary functions and in the tabulated transcendent function

$$f(y)=-\int_0^y \ln(1-u)\frac{du}{u}.$$

Numerical calculations have shown that if the total radiation is divided into three parts with respective wave lengths $\lambda<8\mu$, $8\mu<\lambda<13\mu$ and $13\mu<\lambda$, formulae (1) and (2) can be applied to each of these sections of the spectrum, the section being considered as sufficiently small. The application of formulae (1) and (2) to the total radiation can also be considered as a satisfying approximation. The net flux of radiation $I'-I''$ in any interval of frequencies increases monotonously with the altitude. The general flux (for all frequencies) within the range of the troposphere may be roughly considered (within 20%) as a linear function of the altitude z.

A detailed development of formulae (1) and (2) and the results of numerical calculations of values I' and I'' for different cases are given in a paper in vol. 29 of the Annals of the Leningrad State University, Astronomy.

Astronomical Observatory.
Leningrad State University.

Received
5. I. 1939.

Comptes Rendus (Dóklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

CHEMISTRY

ALUMINIUM AND CHROMIUM COATINGS OBTAINED FROM VAPOURS OF THEIR SALTS

By E. S. SARKISOV

(Communicated by Wl. A. Kistiakowsky, Member of the Academy, 7. XI. 1938)

Izgaryšev and Sarkisov (1) obtained metallic coatings (of chromium, tungsten and others) by displacing with iron the corresponding metals from vapours of their salts at a high temperature. They have shown that iron coated in this manner is sufficiently stable with respect to certain of the most important corroding agents. In the present paper some results of an investigation are given dealing with the displacement of aluminium and chromium by iron from vapours of their salts.

In the processes which we investigated, chemical reaction takes place on the surface of the iron between the solid, metallic phase and the salt of the metal present in the gas phase. However, owing to the fact that the process takes place at a high temperature (900—1000° C), a diffusion process is associated to the displacement reaction. Thus, for example, for the case of the coating of iron with aluminium, besides the reaction $Fe+AlCl_3 \rightleftarrows FeCl_3+Al$, there also occurs diffusion of aluminium into iron and of iron into aluminium. Therefore the reaction does not stop with the formation of an aluminium layer having a thickness of the order of atomic dimensions, but proceeds further owing to the diffusion of iron atoms from within to the interface (metal-gas). The iron atoms, which diffused through, interact with the vapours of aluminium chloride and are removed into the gas phase. Thus, this process is a combination of two simultaneously occurring processes: chemical reaction and diffusion. It is evident that a study of this combined process, besides being of interest from a theoretical point of view, is of great practical interest too. The surface of a chemically unstable metal may thus be enriched with a nobler metal or a metal which easily becomes passive. As seen from experiments, such an enrichment, in contrast with the process of cementation, results in no changes in the form of the surface or volume of the metal treated. Besides, using this method of treatment, the depth to which Al and Cr penetrate into the iron and steel considerably exceeds that obtained by the usual methods of cementation.

In the present investigation the treatment of the samples of steel with aluminium and chromium was carried out in a porcelain reaction tube 80 cm long and 3 cm in diameter. The tube was heated in an electrical oven. In one part of this tube the metallic aluminium (or chromium) was placed, and in another, the steel samples. The vapours of the chlorides were obtained in the reaction tube itself by the action of dry hydrogen chloride on the metal (Al or Cr). Hydrogen chloride was led into the oven with the aid of a cur-

rent of pure electrolytic hydrogen which was passed through strong hydrochloric acid ($d=1.19$). Before entering the oven, the mixture of these gases was dried by passing them through calcium chloride and sulphuric acid. The passage of hydrogen in a mixture with hydrogen chloride was done in order to eliminate the possibility of the oxidation of aluminium during the process and to purify the steel surface from oxides. After the experiment was finished and the reaction tube had cooled, the treated steel samples were removed from the tube and subjected to suitable analysis. Experiments were carried out at various temperatures. The temperature of the oven was measured with the help of a pyrometer in conjunction with a Pt—Pt+Rd thermocouple. The samples employed were prepared from steel having an average carbon content (C=0.4%) and were in the form of small cylinders having a surface of 1.55 and 2.14 cm^2.

The coating of the steel with aluminium was carried out at three temperatures: 850, 1000 and 1150° C. The time of treatment was the same in every case—4 hours. It was found that the aluminium coating formed at 850° is extremely unstable and easily peels off of the steel sample.

Very stable coatings of aluminium, which did not peel off even after a heavy blow, were obtained at 1000° C. The samples in this case had a light-grey colour and their outside surface was shiny and perfectly smooth.

An increase in temperature to 1150° C also improved the quality of the protective layer of aluminium. However, at this temperature the coating possessed a dark-grey colour and was slightly rough. The thicknesses of these coatings are given in Table 1.

Table 1

Temperature of treatment, °C	850	1000	1150
Thickness of the aluminium layer, in mm	0.057	0.252	0.926

From Table 1 it can be seen that, with an increase in temperature (the time of treatment being kept constant), the layer thickness of the protective coating of aluminium increases. This increase is especially marked above 1000° C. For steel having an average carbon content a temperature of the order of 1000° C ought to be considerer sufficient for forming a satisfactory aluminium coating, however, for a deeper saturation of the steel samples with aluminium at 1000° C it is necessary to correspondingly protract the treatment.

A measurement of the cylindrical samples of steel before and after treatment showed that their profiles do not change.

The samples treated with aluminium were tested for stability with respect to the action of illuminating gas. Since technical illuminating gas, in addition to the basic reducing gas (CO), contains some oxygen from the air, this gas, in our opinion, is the most suitable agent for testing the stability of aluminium coatings at high temperatures.

Experiment showed that samples treated with aluminium at 1000 and 1150° C, after the action of illuminating gas over a period of 7 hours at temperatures of 700—800° C, changed neither their outer appearance nor in their lustre; their weight also remained unchanged.

Samples coated with aluminium at 850° C under the same conditions corroded considerably under the action of illuminating gas, the same as steel samples which had not been treated. In these cases the surface of the samples was covered with a durable, black, thin coating and became markedly corroded.

A test of the samples in illuminating gas at 900° C showed the complete stability of the aluminium coatings obtained at 1000° C.

The samples treated with aluminium at a higher temperature (1150° C) display less stability at 900° with respect to corrosion (the influence of illuminating gas), even though they possess a larger layer thickness.

For a study of the microstructure of the protective layer of the samples, cross-sectional slides were prepared which, after preliminary polishing on different sorts of emery cloth, were subjected to polishing with a cloth covered with a suspension of aluminium oxide.

An alcoholic solution of picric acid [5 g of picric acid per 100 cm^3 of alcohol (95°)] turned out to be the best etching agent.

The coating obtained at 1000° C consists of two layers: an outer layer—considerably thinner, shiny and not subject to etching, and an inner layer—thicker and showing a distinct structure after etching.

While the structure of the inner layer was comparatively quick to develop, the structure of the outer layer, even after the protracted action of the etching agent, could not be made out. The characteristic lamellar, dendritic structure of

Fig. 1.

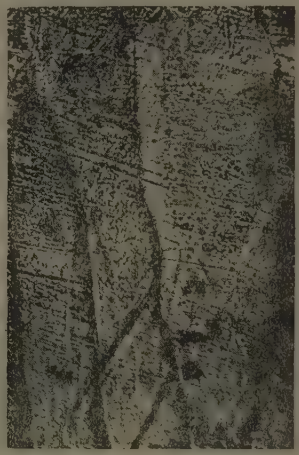


Fig. 2. ×150; $t°=1150°$.

the inner layer (Fig. 1) evidently corresponds to a solid solution of aluminium in iron; this layer was photographed without the outer layer by using a larger magnification. The white and dark parts of the Fig. 1 represent separate crystallites of the given solid solution, differently orientated with respect to the surface of the thin-section.

In the case of the aluminium coating obtained at 1150° (Fig. 2), it could be detected that the whole coating consisted of a single layer whose structure, as can be seen from the photograph, consists of polyhedral grains which are situated perpendicular to the edge of the sample.

These results may, as we believe, be connected with the data obtained by N. S. Kurnakov, G. Urazov and A. Grigorjev(2).

According to these authors, the existence of two layers in the aluminium coating obtained at 1000° C may be explained in the following way: the outer, thinner layer is a certain eutectic of aluminium («the aluminium being present in a predominant amount in this aluminium eutectic»), while the inner layer, possessing a distinct structure, is a solid solution of aluminium in iron.

As to the coating obtained at 1150° C, the only layer which is obtained here seems to be formed at the expense of the endothermic compound Al_2Fe_3, which, being slowly cooled below 1100° C, decomposes and forms a solid, comparatively coarse crystalline solution of aluminium in iron.

The increased resistance to corrosion observed by us in the samples coated with aluminium at 1000° C would be put down to the formation of the previously mentioned thin outer layer (an eutectic with a predominant amount of aluminium), which is absent in the case of the coating formed at 1150° C.

A comparison of the thickness of aluminium coating with those of chromium coatings, obtained under identical experimental conditions, gave values that proved to vary materially (Table 2).

Table 2

Thickness of Coating in mm

Experimental conditions	Temperature	850°	1000°	1150°
	Time of treatment	4 hrs.	4 hrs.	4 hrs.
Coating material	Aluminium	0.057	0.252	0.926
	Chromium	0.032	0.108	0.253

Curve *3* given in Fig. 3 illustrates the marked growth of the thickness of the aluminium coating as compared to the chromium one with the increase in the temperature of the process. For example, if the ratio at 850° amounts to 1.8, then at 1000° C it is already as high as 2.33. An especially sharp increase is observed above 1000° C. Thus, at 1150° C the aluminium coating is 3.66 times thicker than the chromium coating.

Thus, Curve *3* shows by how much the thickness of the aluminium coating exceeds the thickness of the chromium coating at a given temperature; it is evident that this phenomenon is due to the different rates of diffusion of aluminium and chromium within the surface of the steel sample.

The diffussion process for metals is mainly determined by means of the equation proposed by Dushman and Langmuir ([3]): $D = Ae^{-\frac{Q}{RT}}$, where $A = \frac{Q}{Nh}\delta^2$, Q is a quantity which is similar to the energy of activation in chemical reactions, δ is the interatomic distance, N is the Avogadro number, and h is the Plank constant.

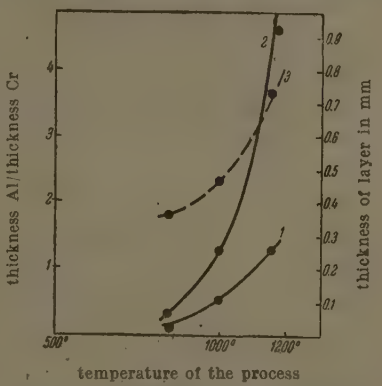


Fig. 3. *1*—Effect of temperature upon the thickness of chromium coating. *2*—Effect of temperature upon the thickness of aluminium coating. *3*—Effect of temperature upon the relation betwen the thickness of Al and Cr coatings.

The quantity Q in the equation is the energy of «loosiness» which is necessary to free a gram-atom of a metal from the lattice and make it mobile. With a decrease in the energy of «loosiness» Q, the coefficient of diffusion D increases.

Owing to the fact that the diffusion of aluminium atoms in our experiments occurs at temperatures which exceed the melting point of this metal (658° C), while the diffusion process for chromium takes place considerably below its melting point (1520° C), the mobility of aluminium atoms should be greater than that of chromium atoms.

Consequently, the energy of «loosiness» Q in the case of treatment of the steel samples with aluminium will be less than that in the case of chromium.

Some decrease in the quantity Q and increase in the rate of diffusion is possibly due to the comparatively great similarity between the crystal lattices of aluminium and iron at a high temperature.

Besides it is necessary to take into account apart from diffusion within an individual grain of the metal also diffusion along grain boundaries. The latter in some cases plays a decisive rôle in processes concerned with the diffusion of metals.

Langmuir ([4]) has calculated the rate of diffusion of Th into W in a monocrystal and along grain boundaries. At 2400° C the rate of diffusion proved to be approximately 100 times higher along the boundaries than within the grain. In our experiments with aluminium a similar kind of diffusion should be of considerable importance, since the mobility of aluminium atoms along grain boundaries, due to its low melting point, will exceed that in the case of chromium.

Consequently, it should be noted that the considerable difference between the thicknesses of aluminium and chromium coatings, obtained under identical experimental conditions, is due to the different nature of the diffusing metals, Al and Cr.

As to the especially marked increase in the ratio of the thickness of the aluminium coating to the thickness of the chromium coating at a temperature above 850° (Fig. 3, Curve *3*), the latter may possibly be caused by a change in the structure of the crystal lattice and in the value of the atomic radius of iron, which occurs at 906° C.

It is known that the space-centered cubic lattice of iron (α) at 906° passes over into a face-centered lattice having the same symmetry (γ). The density and packing of the atoms of a given substance, which are functions of the atomic radius, are also dependent upon the type of lattice.

For a space-centered cubic lattice this dependence is expressed by

$$S = \frac{1.30}{8r^3} A \cdot 1.64 \cdot 10^{-24},$$

while for the case of a face-centered lattice

$$S = \frac{1.41}{8r^3} A \cdot 1.64 \cdot 10^{-24}.$$

Schmidt ([5]) established by means of X-rays that, during the transition from α-Fe$\rightarrow\gamma$-Fe, both the density as well as the atomic radius increase. A change in these factors may, evidently, involve a corresponding change in the quantity Q.

A further more detailed investigation of the physico-chemical nature of the coatings formed, their structure and thickness will give a clearer notion of the mechanism of the procedure studied, which is a combination of two simultaneously occurring processes: chemical reaction and diffusion.

Colloid-Electrochemical Institute.
Academy of Sciences of the USSR.
Moscow.

Received
19.XI. 1938.

REFERENCES

[1] N. Izgaryševa. E. Sarkisov, C. R. Acad. Sci. URSS, XVIII, № 7, 435 (1938); ЖОХ, 8, вып. 9, 830 (1938). [2] Н. С. Курнаков, Г. Г. Уразов, А. Т. Григорьев, ЖРХО, **50**, 270. [3] S. Dushman a. I. Langmuir, Phys. Rev., **20**, 113 (1922). [4] I. Langmuir, J. Franklin Inst., **217**, 543 (1934). [5] W. Schmidt, Erg. d. Techn. Röntgenkunde, **3**, 195 (1932).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

GEOCHEMISTRY

SPECTROSCOPIC CHARACTER OF THE THERMAE OF THE TRANSILIAN ALATAU (TYAN-SHAN)

By I. P. NOVOKHATSKY and S. K. KALININ

(Communicated by N. S. Kurnakov, Member of the Academy, 7. I. 1939)

One of the pecuiliar features of the geology of Tyan-Shan is the presence of thermal springs. Many of those springs are of balneological interest, some are already being utilized for medical purposes.

The thermae of Tyan-Shan were subjected to rather numerous investigations, which established their physico-chemical regime and composition, as well as their relation to geology.

The thermae of Tyan-Shan are slightly mineralized (from 0.27 to 1.8 g/l of dry residue) radioactive warm and hot springs, containing sodium sulphate, some hydrogen sulphide, their gas content being of almost pure nitrogen. The dry residue is characterized by a high content of silicic acid (1).

Within the Transilian Alatau Range are known several groups of thermae, among them are the springs Alma-arasan, Talgar, Turgen, Gorelnik and others. These thermae are characterized by their group-arrangement, which is accounted for by the structural peculiarities of the feeding fissures.

To give an idea of the composition, we give below the analysis of water from the Alma-arasan spring No 1 (2).

	g per l
KCl	0.0092
$NaCl$	0.0151
Na_2SO_4	0.0712
Na_2CO_3	0.0684
$Ca(HCO_3)_2$	0.0065
$CaSO_4$	0.0073
$MgSO_4$	0.0021
$NaHS$	0.0073
H_2SiO_3	0.0722
Total	0.2593 g

The above analysis lacks completeness: besides the substances registered, the thermae contain a number of elements, the presence of which can be detected using more accurate methods of analysis. The authors subjected to spectroscopic analysis the dry residues of 16 thermae of the Transilian Alatau.

The results of the analysis are tabulated below.

From this table it may be seen that the thermae of the Transilian Alatau contain admixtures of a number of elements. Quite typical is the

	Al	Fe	Mo	Cu	Zn	Pb	Ni	Li
1. Alma-arasan group (5 springs)	+	+	+	w. l.	w. l.	w. l.	—	w. l.
2. Talgar group (10 springs)	+	+	+	+	w. l.—	w. l.	+	w. l.—
3. Gorelnik (1 spring) .	w. l.	+	+	w. l.	w. l.—	w. l.	—	w. l.—

	Sr	B	Ag	Sn	Ge	Mn
1. Alma-arasan group (5 springs)	w. l.	—	w. l.—	w. l.—	w. l.—	w. l.
2. Talgar group (10 springs)	w. l.	w. l.—	w. l.—	w. l.—	w. l.—?	w. l.—
3. Gorelnik (1 spring) .	w. l.	w. l.—	w. l.—	—	—	—

Note: +, intensive lines; w. l., weak lines; w. l. —, very weak lines; —, substance failed to be detected.

presence in all cases of molybdenum in quantities varying from 0.001 to 0.06% (per dry residue). The above determinations have been chemically checked. It should be noted that several showings of molybdenum mineralization are known in the Transilian Alatau.

Admixtures of both iron and aluminium, as well as of alkaline metals, lithium and strontium, are of frequent occurrence. Among mineralizers boron should be mentioned. In some samples have been detected: copper (almost everywhere), lead and zink. The Talgar group is characterized, moreover, by the presence of nickel.

The above analyses of thermae may be of some balneological interest when viewed under the aspect of the physiological effect produced upon the organism by a given element. Besides, the analyses may contribute to the knowledge of the metallogenesis and geochemistry of the region.

Kazakhstan Branch
of the Academy of Sciences of the USSR.
Alma-ata.

Received
8. I. 1939.

REFERENCES

[1] Э. Э. Карстенс, сб. Термы и газы Тянь-Шаня (1938). [2] Н. Н. Литвинова, Курорты и леч. местности Казахстана (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

MINERALOGY

IDENTITY OF THE INDER ASCHARITE AND CAMSELLITE

By T. N. AGAFONOVA and E. W. ISKÜLL

(Communicated by E. A. Fersman, Member of the Academy, 15. I. 1939)

In studying the borates of the Inder region there arose, naturally, the problem of identifying them with the minerals already described (1).

As regards chemical composition, three minerals, viz. camsellite (2), szaibelyite (3) and the ascharite from the Stassfurt mines (4) bear close resemblance with a certain type of the Inder borates known in literature as «ascharite», while the first and the second of them extend this similarity to the physical properties too.

Yet, there is sharp difference in the optical properties between Stassfurt ascharite and Inder borate, which forbids to apply the name «ascharite» to the latter. On the other hand, the lack of X-ray data on szaibelyite precludes for the present any detailed comparison with this mineral.

Camsellite from British Columbia which has been described by Gruner (2), as well as the Inder ascharite investigated by the authors, both are of the same chemical composition—2 $MgO.B_2O_3.H_2O$ (Table 1).

Their physical properties are the same: both are white minerals, consisting of fine fibres, density ~2.6, with a straight extinction, negative elongation and refractive indices $N_g=1.649\pm0.003$ and $N_p=1.575\pm0.003$. We give

Table 1

Composition	Camsellite(2)	Inder ascharite (5)
MgO	45.24	46.14
MnO	1.09	—
FeO	1.28	—
Fe_2O_3	0.85	—
Al_2O_3	0.29	0.32
B_2O_3	40.40	38.61
H_2O, + 110°	10.55	12.28
H_2O, — 110°	0.26	
SiO_2	—	1.33
K_2O	0.04	—
P_2O_5	—	0.02
SO_3	—	0.33
CO_2	—	0.28
Total	100	100.24

no refractive index N_m differing from N_g and N_p, which has not been suggested by Gruner either, since the too fine fibrous structure of that mineral defies sufficiently accurate determination. Winchell ([6]), however, succeeded by means of a cleverly constructed device in measuring the refractory index N_m for camsellite, which proved=1.620.

A roentgenometric investigation of camsellite after Debye's method was made by Gruner on copper filtered radiaton; the reflection angles θ were determined by measuring the powdergram. No further calculations, however, were made by him. The Inder ascharite was studied by the authors under the same experimental conditions. When comparison of the structure of both minerals is aimed at, it suffices to compare their respective reflection angles and the relative intensities of the Debye-lines ([7]) tabulated below.

Table 2

Camsellite		Inder ascharite	
θ	*I*	θ	*I*
7°06′	v. st.	7°06′	v. st.
8°34′	m.	8°34′	m.
13°45′	m.	13°47′	m.
14°51′	m.	14°53′	m.
15°51′	m.	15°48′	m.
16°51′	v. st.	16°51′	v. st.
17°39′	v. st.	17°39′	v. st.
18°31′	st.	18°31′	st.
19°28′	st.	19°28′	st.
20°27′	v. st.	20°27′	v. st.
21°45′	st.	21°45′	st.
22°40′	st.	22°40′	st.
23°28′	w.	23°27′	w.
25°33′	m.	25°33′	m.
26°25′	m.	26°26′	m.
27°04′	w.	27°03′	w.
28°36′	m.	28°35′	m.
29°49′	st.	29°49′	st.

Gruner gives only the results of visual determination of the relative intensities of the lines. We therefore give no microphotometric data either, confining our work to visual estimation.

From Table 2 it follows that the two minerals cannot be distinguished by their structure, since their reflection angles as well as the relative intensities of the Debye-lines coincide in the powdergrams made.

Identical chemical composition, structure and physical properties of camsellite and Inder ascharite point to the fact that two terms are in literature to denote one and the same mineral. Inder ascharite is no new mineral, but should be considered as camsellite, as it had been previously determined.

X-ray Laboratory
of the «Mekhanobr» Institute.

Received
11. I. 1939.

REFERENCES

[1] М. Н. Годлевский, Зап. Мин. общ., XVI, 2, 315 (1937). [2] J. W. Gruner, Am. Min., 11, 509 (1932). [3] W. T. Schaller, Am. Min., 13, 230 (1928). [4] E. S. Larsen a. H. Berman, The Microscopic Determination of the Non-opaque Minerals (1934). [5] Н. Н. Кочкин, Отчет № 2632 Ин-та Механобр. [6] A. N. Winchell, Am. Min., 14, № 2, 48 (1932). [7] Б. Делоне, Н. Падуров, В. Александров, Матем. основы структурного анализа кристаллов, 276 (1934).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

PETROGRAPHY

ZUNYITE AND ZUNYITE ROCK OF KARABAS

By K. I. ASTASHENKO and V. A. MOLEVA

(Communicated by F. Loewinson-Lessing, Member of the Academy, 25. XII. 1938)

In 1937 fragments of a pistachio-green heavy rock were found in the southern part of the secondary quartzite massif Karabas; attention was called to this rock because of its colour, sharply contrasting with the monotonous grey secondary quartzites. Microscopic examination of this rock has shown it to consist of the colourless mineral zunyite, enclosed in a finely-disperse pistachio-green cement.

Additional field studies (1938) established that the zunyite rock occurs in a vein in secondary diaspore-sericite quartzite. The massif Karabas, where the zunyite rock was encountered, is located 35 km north-westward from the Kounrad mine and 50 km northward from the Lake Balkhash and the town of the same name.

The following rocks take part in the geological structure of the Karabas: the oldest Middle Devonian effusive quartz porphyres and albitophyres compose the periphery of the Karabas. The effusive beds are intruded by granodiorite-porphyres. In the apical portion the granodiorite-porphyres are transferred into secondary quartzites, which are most widely spread among the above rocks. A small body of unaltered granodiorite-porphyres has been developed westward from Karabas. The secondary quartzites are in turn intruded by small dykes of pink microgranite-porphyres and diabase-porphyrites, quartz and quartz-tourmaline veins, and veinlets of barytes and zunyite rocks.

The mineral zunyite was first encountered and described in 1883 by W. T. Hillebrand ([1]) at the Zuny Mine, Silverton, Colorado. In the USSR it was found first in 1929 by N. N. Kurek ([4]) in secondary quartzites of the Sekissov deposit of refractory clays at the Altai. In Kazakhstan zunyite has been first found by K. I. Astashenko among the secondary quartzites of the Karabas. Information as to this finding was published by N. I. Nakovnik in 1938 («Soviet Geology», № 11). The same year zunyite was found by Prof. E. A. Kuznetzov at the massif Djaman-Arganaty, and by P. S. Markov at the massif Koshan.

Among the secondary quartzites of the Karabas zunyite is developed in two forms: 1) as a zunyite vein, 2) in small accumulations of irregular form (sample № 147).

A zunyite vein 30 cm thick has a sharp contact with the enclosing diaspore-sericite secondary quartzites. Macroscopically numerous white shiny crystals of zunyite are observed, enclosed in a finely disperse mass. Under

the microscope zunyite is but rarely observed in the form of perfect crystals of 0.01—1.0 mm in size. Numerous crystal fragments irregularly disseminated in the cementing mass are prevalent. The distribution of the mineral is clearly seen in Fig. 1.

With one nickol the mineral is colourless. It constitutes 50—60% of the rock. The zunyite is intergrown with needles of rutile. The cement mass cannot be determined more accurately even in case of maximum magnification.

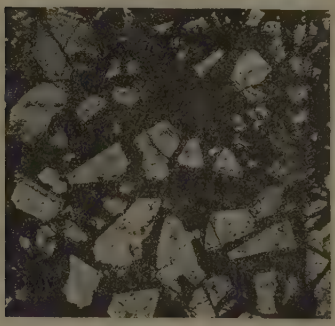


Fig. 1. Zunyite. Dark portion—cement mass.

With crossed nickols the mineral is either isotropic or anisotropic; in the latter case it possesses a zonal structure with a subsequent alternation of bands, arranged parallel to the crystal faces. The bands have a grey interference colouring of the first order. The birefringence, measured by Bereck's compensator, is 0.002. Straight extinction with regard to the crystal faces. Refraction indices of different zones are different and vary from 1.590 to 1.594 $\pm$ 0.002. In sample № 147 zunyite has a lower refraction index, 1.587$\pm$0.002.

For the purpose of further studies the zunyite rock has been ground, wasted and separated by heavy liquids and an electromagnet into two fractions: zunyite and cementing mass.

A goniometric examination of the mineral has shown that the crystals have three forms of development: 1) simple tetrahedra; 2) combinations of two tetrahedra; 3) combinations of two tetrahedra and a cube. The latter form has been first established for zunyite (Fig. 2).

Chemical investigation of the zunyite, the cement and the general composition of the rock has been made in the Chemical Laboratory of the Insti-

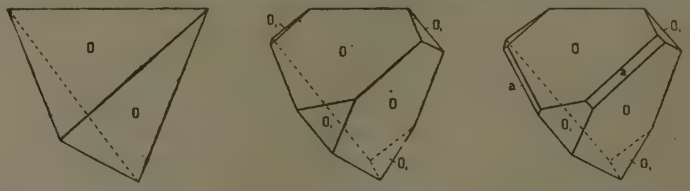


Fig. 2. Forms of zunyite crystals. Specific gravity 2.894; hardness 7.

tute of Geological Sciences by the chemist V. A. Moleva. For comparison are given analyses of zunyites from America and South Africa (Table 1).

From these analyses it may be seen that the zunyite under description contains more SiO_2 and TiO_2, as compared to foreign minerals. The increased content of these oxides depends on the minute ingrowths of rutile, which could not be eliminated in spite of the most thorough sorting.

According to their fluorine and chlorine content two varieties of zunyites are distinguished. The zunyite from Karabas is referred to the fluorine group.

Besides the above methods the zunyites and the cement mass have been studied in the Physico-Chemical Laboratory of the Geological Institute of the Academy of Sciences of the USSR by N. V. Belov. When comparing the X-ray diffraction patterns of our mineral, obtained by N. V. Belov, with the X-ray diffraction patterns of zunyite from the Zuny Mine, given by Gossner, their full identity is quite obvious (Table 2).

Table 1

Oxides	Karabas			America			S. Africa—Postmasburg		
	Zunyite	Cement	Bulk	Zunyite, Zuny mine	Red Mount	Guatemala	Vitreous transparent zunyite	Zunyite from fine-grained diasp. rock	Zunyite from coarse-grained diasp. rock
SiO_2	25.53	8.10	12.60	24.33	24.11	25.10	29.10	24.25	24.10
TiO_2	0.62	1.06	0.86	—	—	—	—	traces	traces
Al_2O_3	57.42	32.58	37.94	57.88	57.20	57.23	54.25	56.75	56.85
Fe_2O_3	0.10	5.68	4.24	0.20	0.61	1.58	0.50	1.30	1.45
FeO	—	0.22	0.14						
MnO	traces	traces	traces	—	—	—	—	—	—
MgO	0.03	0.06	0.05	—	—	—	traces	0.40	0.30
CaO	0.10	0.26	0.24	—	0.11	—	»	0.35	0.20
SrO	0.001	—	—	—	—	—	—	—	—
PbO	—	13.93	10.72	—	—	—	—	—	—
CuO	—	0.63	0.48	—	—	—	—	—	—
Na_2O	0.17	0.42	0.36	0.24	0.48	0.18	traces	1.65	1.45
K_2O	0.11	2.30	1.80	0.10	—	—	»	traces	traces
P_2O_5	0.56	1.50	1.20	0.60	0.64	0.53	0.15	0.25	0.25
SO_3	—	15.10	11.90	—	—	—	—	—	—
Cl	2.56	0.80	1.20	2.91	2.62	2.75	2.45	3.50	4.80
F	5.52	2.02	2.80	5.61	5.81	5.43	0.80	0.50	0.40
AS_2O_5	—	5.25	4.08	—	—	—	—	—	—
Sb_2O_3	—	0.40	0.31	—	—	—	—	—	—
H_2O, +110°	10.03	10.60	10.48	10.89	11.12	10.61	13.45	11.40	11.65
H_2O, —110°	0.12	—	—	—	—	—	0.90	—	—
Total	102.85	100.91	101.40	102.76	102.70	103.41	103.60	100.75	101.80
F+Cl	2.90	1.03	1.45	3.02	3.03	2.90	0.90	1.00	1.30
	99.95	99.88	99.95	99.75	99.67	100.51	100.70	99.75	100.50
Spec. gravity	2.894	—	—	2.875	2.876	—	2.873	2.884	2.893

On the basis of the above data it has been established that the mineral found by the authors is actually zunyite. Considering the chemical analysis data and X-ray diffraction patterns, N. V. Belov assumes that the empirical formula of zunyites from Karabas is identical with the general formula of zunyites established by Linus Pauling ([5]):

$$SiO_4Al_{12}\,(OH,F_{18})\,Al\,Si_4O_{16}Cl.$$

Table 2

Zunyite from the Zuny mine	Zunyite from Karabas
14°7′	13°55′
16°29′	16°40′
21°13′	21°07′
22°27′	22°35′
25°8′	25°14′
27°58′	27°51′
30°20′	30°22′
33°29′	33°28′
35°5′	34°50′
37°30′	37°21′
40°55′	40°44′

Owing to its finely disperse structure the cement mass was less accurately studied. Chemical analyses established that lead, arsenic, antimony and copper sulphates enter its composition. On the basis of the X-ray diffraction patterns it may be assumed that it consists of two minerals typical of the supergene zone: mimetisite, $3As_2O_8Pb_3PbCl_2$,

and anglesite, $PbSO_4$. In the composition of our memitisite, fluorine is dominating over chlorine, the former being evidently isomorphously substituted for chlorine.

It has been previously shown that at the Karabas massif zunyite enters the composition of secondary quartzites as a rock-forming mineral, but is very rarely encountered. The bulk of it is concentrated in the vein in association with lead and arsenic sulphates.

The first phase of zunyite isolation coincides with the initial stage of the formation of secondary quartzites derived from granodiorite-porphyres at the contact of the latter with quartz porphyres. The high temperatures and the pneumatolytes in the endocontact zone contributed to the low fixation of fluorine and chlorine in the zunyite.

The principal phase of zunyite formation is connected with post-magmatic processes. Towards this time the formation of secondary quartzites was completed in the apical portions of the granodiorite-porphyre body. The subsequent non-uniform cooling and contraction of the apical summit contributed to the formation of fissures into which the pneumatolytes and thermal solutions rushed from deeper zones. In this onrush the zunyite crystals were broken and crushed. The sharp contact with the enclosing rocks and a high degree of crushing in the crystals corroborate the above assumption.

From the foregoing it follows that the formation of zunyite took place in two phases. So far the secondary quartzites of Kazakhstan and of Karabas in particular have been considered as fields of copper and minerals with a high alumina content. Our investigation has established that alongside of the concentration of copper and minerals with a high alumina content, zunyite together with lead, arsenic and antimony sulphides is formed in secondary quartzites. Thus, a new interesting object of investigation is outlined. The next problem of the geological prospecting work on secondary quartzites is to find industrial concentrations of new ores.

Institute of Geology.
Academy of Sciences of the USSR.
Moscow.

Received
30. XII. 1938.

REFERENCES

[1] W. T. Hillebrand, Bull. Geol. Surv., 20 (1885). [2] S. L. Penfield, Am. Journ. of Sci., 45 (1893). [3] T. Nell, The Mineral. Magazine, № 128 (1930). [4] Н. Н. Курек, Тр. ГГРУ, вып. 7 (1930). [5] Linus Pauling, ZS. f. Kristall., 84 (1933).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

GEOLOGY

TRACES OF GLACIAL CLIMATE IN THE OLDER PALEOZOIC OF PODOLIA

By L. LUNGERSHAUSEN

(Communicated by A. A. Borissiak, Member of the Academy, 10. I. 1939)

The Paleozoic deposits of the Dniester basin may be subdivided into three different series. The upper of them consists of greenish-grey limestones, less frequently of dolomites and clayey shales with abundant Gothlandian fauna (the Kamenetz series); the middle one is composed of various unfossiliferous argillo-arenaceous and argillaceous shales (the Ushitz series); to the lower division are referred the most typical coarse-grained arkose sandstones directly overlying crystalline rocks (the Mogilev series).

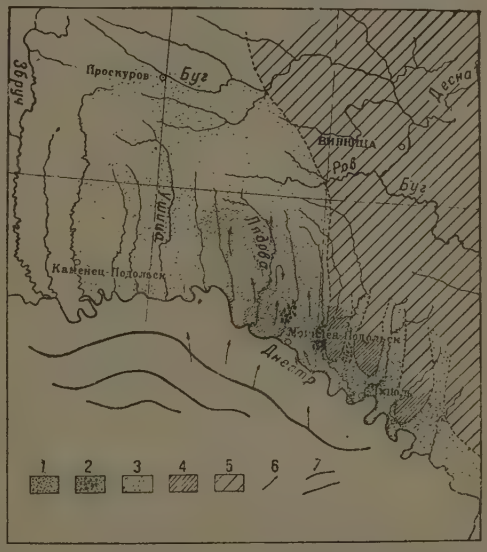


Fig. 1. Paleogeography of the Olchadaev phase. *1*—Fluvioglacial systems. *2*—Boulder breccia, gigantic cauldrons, etc. *3*—Assumable region of distribution of fluvioglacial systems. *4*—Older land (plateau), not overflown by waters. *5*—Assumable outlines of the Bug-plateau. *6*—Direction of fluvioglacial streams. *7*—Southern mountainous country (Paleo-Scythia), covered with melting glacier.

Originally (in the last century) the above formations were regarded as different facies of the same complex, i. e. there was assumed a horizontal replacement of limestones by clays, of clays by sandstones etc.; not until later has been found out the true sequence of the beds, namely, the occurrence of sandstones at the base of the Podolian Paleozoic and that of limestones at the top of the latter. Up to recently, however, the arkose sandstones (our Mogilev series) have been associated with the Silurian sea, being regarded as the neritic facies of its sediments.

First, the author wishes to show in the present note that the Mogilev series is in no way connected with the Silurian marine sediments, but is a quite independent stratigraphical complex, which should evidently be referred to the Cambrian; secondly, that the Mogilev series is no marine, but a continental sediment, and third, that this series had been deposited under specific conditions, most likely under those of a peripheric preglacial province.

The Kamenetz and Ushitz series, whose total thickness seems to be about 1 km, make up a continuous series of sediments of a single basin. Even at the boundary of these, facially quite different series, no traces of unconformity or even of a regional break in the process of sedimentation have been observed. Such a break and a quite distinct one, bearing all characters of an unconformity, can be traced lower, at the boundary of the Ushitz series and the Mogilev sandstones. The surface of the latter has been eroded and destroyed by ancient denudation, and carries a wonderful orange-red or reddish-brown ferruginous weathering crust, which has been but occasionally preserved: the waters of the advancing Ordovician sea should have swept away the cover of friable continental sediments and the eluvial caprock of arkose sandstones. The Kamenetz limestones almost completely correspond to the Gothlandian system; paleontological data are now available that testify to the Ordovician age of the clayey shales (Vascautanu). There are reasons to suppose that the lower portions of the Ushitz series may belong even to the Tremadoc stage. Then the quartz-feldspar sandstones of the Mogilev series should be referred to the Cambrian, while the considerable break between these sandstones and the Ushitz shales may belong either to the Cambrian or to the Lower Ordovician.

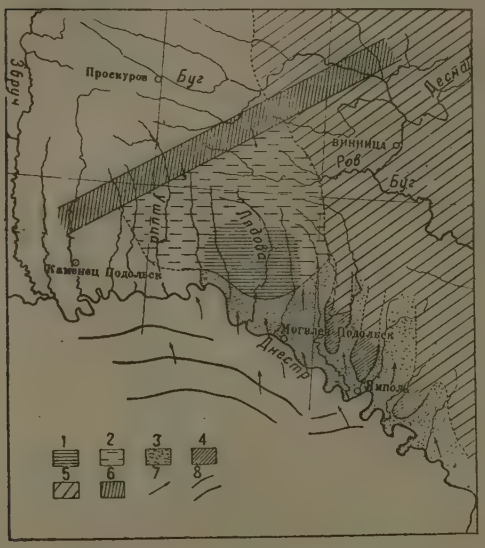


Fig. 2. Paleogeography of the Lomozov phase. *1*—Glacial-lacustrine facies. *2*—Their assumable distribution. *3*—Fluvioglacial (arenaceous) facies. *4—5*—Plateau, not overflown by waters. *6*—Tectonic barrier. *7*—Direction of streams. *8*—Mountainous country (Paleo-Scythia).

A very persistent mineral association (crushed quartz, microcline, acid plagioclases, biotite, muscovite, zircon, garnet, monazite, tourmaline, sphene, etc.) enters the composition of the Mogilev arkose; a typical drawback, assuming still more importance when compared with the overlying (Ushitz) shales and sandstones, is the absence of glauconite, basic plagioclases, an almost total absence of pyroxene, amphiboles, etc. A study of the mineralogical composition of the arkoses permits of the conclusion to be made that the products of disintegration of crystalline rocks, similar to those of Podolia, but at the same time differing from these in some essentials (absence of basic rocks, etc.), served as initial material for these arkoses. The degree of preservation of the minerals, especially the unusual freshness observed even in the least stable of them, leads us to another conclusion, namely, as

to the climate of the Mogilev epoch: the sharp predominance of processes of physical disintegration (accumulation of rubble, pebbles, boulders) over the chemical weathering of the rocks makes it possible to conclude that the climate was severe. This conclusion assumes particular importance in connexion with other data, which will be discussed in the following.

The arkose sandstones show everywhere a wonderful cross-bedding, occasionally of periclinal type. As a rule, this cross-bedding shows a trend to the north; the same northern direction of ancient streams and rivers is also pointed out by fossil ripple marks, in particular, by giant ripples of the progressive sand wave type, arising in case of maximum rapidity of the stream.

The analysis of such facts brings us to the conclusion that southward from Podolia, possibly at the site of present Bessarabia, there was lying a mountain ridge or plateau, from which a fan of violent streams was rushing northward.

Thus, the arkose sandstones are sediments of flowing water; this conclusion may be regarded as having a sound foundation. They are, however, no river sediments. Accumulation of coarsely washed pebbles and rubbles, isolated giant boulders, embedded in the arkoses, the absence of grading in the material, combinations of coarse pebblestones and rubbles with fine sands, the wide scope of the cross-bedding (i. e. the vertical component of the oblique flows of sandstone) and the great amplitude of the ripple marks, all these show that we have here sediments of powerful and irregular streams of great power and rapidity, but without a definitely fixed bed, i. e. fluvioglacial streams.

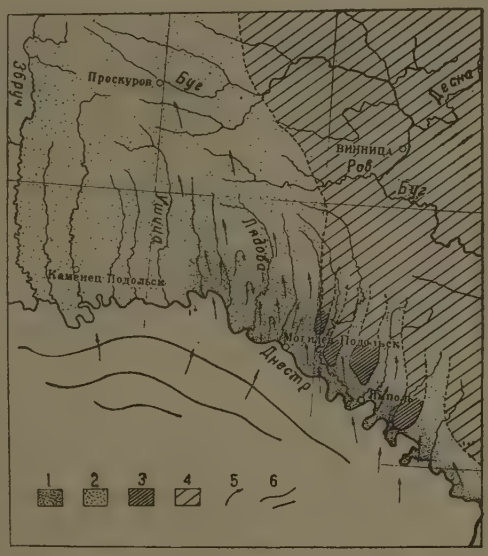


Fig. 3. Paleogeography of the Yampolsky phase. *1*—Fluvial systems. *2*—Region of their assumable distribution. *3—4*—Plateau. *5*—Direction of river streams. *6*—Paleo-Scythia.

In short, we have here a peripheral zone (province) of the Cambrian glaciation. The glacier situated further south did not reach these latitudes. Glacial grinding of the crystalline bed is absent here; the deep cavities (pockets), however, cut into the granits and filled with rounded boulders of great size, i. e. formations of the type of gigantic glacial cauldrons (the Nemiya river), bear evidence of the proximity of the glacier. Among wide fields of fluvioglacial streams isolated islands are elevated, covered with thick beds of ancient eluvium; isolated blocks of dead ice and frozen ground seem to have been preserved here for a long time.

In the vertical direction the Mogilev series is subdivided into three horizons; the lower (the Olchadaev horizon, typically fluvioglacial), the middle (the Lomozov horizon, fluvioglacial and glacial-lacustrine) and the upper (the Yampolsky horizon, fluvial, formed during the epoch of an almost complete

Stratigraphical subdivisions			Main features of physico-geographical history
Pre-Cambrian	Oldest metamorphized sedimentary series pierced by numerous intrusions		The geosynclinal phase of the Upper Pre-Cambrian is completed by the orogonic phase. At the site of half Bessarabia (also the Carpathian?), stretching further towards the Mariupol-Berdyansk massif, a mountain ridge or a large plateau is arising, which is an important element of the structure of the country during the Pre-Cambrian and Cambrian, and partly (the Donetz basin) during the Devonian and Anthracolythic time
	Very large break		Erosion. Development of the complex relief of the crystalline bed
Cambrian (?)	Mogilev series	Olchadaev horizon (respectively—Olchadaev phase)	The southern mountainous country (Paleo-Scythia) is covered with glaciation. The region of direct glaciation is inaccessible for investigation owing to later subsidences. Along the northern periphery of glaciation relicts of gigantic cauldrons and bouldery breccia are preserved. Towards the close of the glaciation powerful streams of fluvioglacial waters cover the northern piedmont plain with sediments of coarse-grained sands and rubble, isolated boulders up to 0.5—1 m in diameter. Only isolated islands covered with an eluvial mantle remain free of water (Fig. 1)
		Lomozov horizon (—phase)	The normal drainage of the fluvioglacial waters from south to north is obstructed by a tectonic uplift directed WSW, which is forming a high barrier (Fig. 2). In front of this uplift a supported lake is formed; in this argillo-arenaceous and argillaceous sediments are deposited, showing a fine seasonal lamination
		Yampolsky horizon (—phase)	Supported waters surmount the tectonic barrier; the lake disappears. A normal system of streamlets, streams and rivers is established, depositing arenaceous sediments of the common river sediment type (Fig. 3) upon the surface of the valley which is flat or gently sloping towards the north. As before, the rivers are flowing consequently from the south to the north. This is the epoch of the last, already faint repercussion of the past glaciation
Large break (weathering crust)			The accumulation of conglacial* arenaceous and clastic sediments (Olchadaev and Yampolsky) ceases. The climate becomes warm (hot?). The sandstones of the Mogilev series become eroded and weathered (orange-red and brown ferruginous eluvial horizon). The southern mountainous country subsides owing to violent disjunctive dislocations. At the same place a depression is formed, which receives the water of the coming Ordovician transgression. From this time up a new correlation of the elevations in the western part of the Ukraine is firmly established: the elevations in the north, the subsidences in the south
Ordovician (Ushitz series)			The deposition of a large series of argillaceous and argillo-arenaceous shales within the sea basin (marine and lagoon facies). The regions supplying terrigene sediments are now the northern regions instead of the southern ones, which results in a quite different nature of the mineral association characteristic of the Ordovician beds

* Accompanying the glacier (term suggested by D. N. Sobolev).

stopping of glacial phenomena). The formation of the supported lake in the Lomozov phase may be put down to the influence of the large uplift of a WSW—ONO direction which rose at the time northward from our region (Letichev, Dunayevzy) and formed a barrier for the waters. Later on the waters partly surmounted this barrier and the normal drainage to the north was restored (the Yampolsky phase). The assumable course of paleogeographic events, as occurring within the Mogilev epoch, is given in the summarized scheme.

Institute of Geology.
Academy of Sciences of the Ukrainian SSR.

Received
28. XII. 1938.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

GEOLOGY

STAGES OF DEVELOPMENT OF THE DNIEPER-DONETZ DEPRESSION

By L. LUNGERSHAUSEN

(Communicated by A. A. Borissiak, Member of the Academy, 10. I. 1939)

1. In the history of the development of the Dnieper-Donetz depression may be distinguished several phases of its existence as a depression proper (or the geosynclinal) and as a platform.

2. Our knowledge concerning the Pre-Carboniferous history of the depression is lacking certainty. It should be supposed that not only during the Devonian, but during the Pre-Devonian too, the Dnieper-Donetz basin played the part of a piedmont depression with regard to the ancient mountainous country situated further south, which continued the problematic range that is supposed to have bordered Podolia from the south during the Cambrian, and to have stretched further east, overlapping the outline of the actual crystalline massif. The so-called Devonian deposits of the Donetz (that may be made up also of equivalents of older, Pre-Devonian formations) are for the most part typical peripheric platforms accumulating products of the mountain range disintegration.

3. The first phase of the geosynclinal existence of the Dnieper-Donetz basin safely known is the Anthracolythic. The huge beds of sediments which accumulated during this phase (the Donetz basin) were formed under quite peculiar epeirogenic conditions of regular, rythmical recurrence of upheavals over a small range (fluvial sediments), alternating with extensive regional subsidences, the latter being accompanied by setting in of a lacustrine-marshy landscape (clay, coal). A vertical section through the Anthracolyth series shows a great number of completed and partly imperfect (less frequently) continental-marine cycles. The complex of sediments of each cycle is separated by erosions from the underlying beds and begins with sandstones of the fluvial type (maximum uplift). Further upward the latter are replaced by lacustrine-fluvial, lacustrine and boggy sediments (coal). The maximum subsidence coincides with a short transgression of the sea. It is of importance to note the stability of the conditions described during the entire second half of the Anthracolythic stage, i. e. the constancy both of the general trend towards subsiding, typical of the geosynclinal and subgeosynclinal conditions, and the nature of those small convulsive movements of the epeirogenesis (rhythmical respirations), responsible for the remarkable cyclicity of the processes of sedimentation. North-west from the Donetz basin (the Dniester-Donetz depression s. str.) the continental conditions are probably more rigourous, and the facial type of the sediments becomes somewhat altered.

4. During the Upper Carboniferous the outlines of the future tectonic structures began to shape, though yet in an indistinct form. At the same time started the formation of original subsequent hydrological systems (streams and rivers) contemporaneous with the Araucarite series, the direction of those systems being subject to manifold changes (transformations) due to the variability of the landscape. The geography of the saliniferous Lower Permian lagoons did not escape the influence of the originating tectonic structure (upheavals and depressions) either.

5. Hercynian movements interrupt the prolonged geosynclinal phase of the Anthracolythic time. These movements might correspond to the Pfalz, or possibly to as early a phase as the Saal of Western Europe. The whole complex of rocks including the series which may be regarded as parallel to the lowermost horizon of the Permian (saliniferous beds) is found to be disturbed; undisturbed and unconformably overlying the Hercynian structure are red-coloured sandstones and conglomerates which may be referred as far back as to the Permian, namely to the Middle and Upper Permian, since they are clearly separated from the Triassic kaolinized sandstones and have apparently been formed under quite different conditions. It seems probable that the Hercynian dislocations have been strictly confined to a certain period of time and that the part played by the preparatory (Upper Carboniferous) movements in the formation of the basic structure was rather unimportant.

6. Due to the Hercynian movements the Dnieper-Donetz depression, where geosynclinal conditions were prevailing, became transformed into a typical platform, massif. Even in the south-easternmost region, the Donetz basin, continental conditions were established (intensive denudation), though the great thickness of sediments (red-coloured and Triassic series) points to a process of slight subsidence, damping in the north-west direction.

7. An important turning-point in the development of the geological conditions coincides with the Lower Jurassic. The tendency towards depression formation becomes once more evident. Continental conditions are replaced by sea conditions. In the south-east (the Donetz basin) this moment is usually referred to the Lias; further north-westward the transformation of the continental platform into a depression occurs somewhat later, in the central part not before the Bajossian, and in the peripheral parts during the Bathonian.

8. The Jurassic depression (the last ages being referred to the Oxfordian—Romny) has been closed by the tectonic movements of the young Cimmerian phase. The rôle of these movements in the formation of the Donetz basin has been long established (A. A. Borissiak, Member of the Academy); at present we ought to admit their importance with regard to the Dnieper-Donetz depression too. The late Cimmerian phase traces a new stage of its development, which is brief but most typical: continental conditions become prevalent once more (typical platform). As relicts of this continental epoch (close of the Jurassic, first half of the Cretaceous) have been left behind fluvial sands and pebbles, as well as ravine and deluvial accumulations (the Donetz basin, Romny, Kanev).

9. During the Upper Cretaceous time a depression is formed again. The Cenomanian deposits are still of the type of usual platform sediments, but the overlying beds of monotonous white chalk point to the prevalence of subgeosynclinal conditions. The geosynclinal type is to a certain extent preserved also by the overlying Paleogene beds, although the zone of depression s. str. becomes narrower during the Paleogene stage.

10. Towards the close of the Oligocene (or at the beginning of the Aquitanian) the Donetz basin loses its last sea, and platform conditions are esta-

blished which prevail up to the present time (influence of the Alpian orogenesis?).

11. The analysis of the Romny structure gave a new turn to the interpretation of the tectonics of the Dnieper-Donetz depression. Till recently the opinion was universally adopted that this structure is a typical saline boss, intruding the Upper Paleozoic, Mesozoic and younger beds, i. e. the whole of the structure being actively formed by salt. The finding of Devonian fauna at Issachky gave rise to ascribing the salt, previously considered as Permian, to the Devonian age. The author firmly disagrees with this opinion. The examination of the sections of bore-holes at Mt. Zolotukha and its northern limb, as well as an attempt to graphically analyze them, leads to the conclusion that we face here a Pre-Cretaceous, namely a late Cimmerian fold, whose core is broken by a system of fissures and fractures accompanied by the formation of local large overthrusts directed from south to north. According to this interpretation, the saline mass of Mount Zolotukha has been squeezed into the central (core) portion of the anticline under the influence of late (posthumus) subsidences of the southern limb. The history of the development of this complicated structure may be represented as follows: the Hercynian movements, closing the geosynclinal phase of the basin's life, produce a system of broad inclined folds, strongly eroded during the following (Pre-Jurassic) continental epoch. Owing to these erosions, the regions of the development of the Permian saliniferous beds, which had from the very beginning the aspect of isolated lacustrine-lagoon spots, became reduced to a minimum (absence of salt at the northern limb of the Romny anticline). Towards the close of the Jurassic the Paleozoic layers, together with the series of Jurassic clays which was loosely and unconformably overlying them, formed an anticline of an almost latitudinal direction (WNW), complicated by overthrusts and broken by fissures, along which effusions of diabase-basalts (first phase of effusion) took place. The fold becomes eroded during the Lower Cretaceous and is unconformably overlain by sediments of the Cenomanian sea. The next important phase of development of the Romny structure is referred to the Upper Cretaceous, evidently to the Santonian. The movements of this time (Sub-Hercynian phase) hardly produced any folded forms and were restricted to vertical shifts on a large scale, namely to a subsidence of an enormous portion of the southern limb of the anticline; the latter pressed salt masses into the central part of the anticline, the most dissected by fissures, fractures and overthrusts. With the same movements coincides the second (principal) phase of diabase-basalt effusions, fragments of basic effusive rocks of the first phase (Korovnichenko) being found among breccia in the zone of contact influences of the latter. Vast masses of the tectonic breccia, raised by overthrusts and by the active ascent of the salt, are washed out in the Santonian sea; an original local facies of conglomerates enveloping the Romny island is produced at their expense.

12. The above interpretation explains the appearance of the Devonian together with the salt (Issachky). The Devonian rocks represent parts of the deep core of the fold squeezed out in the course of the overthrust process. The assumption of the Devonian age of the salt proves unnecessary, though it would by no means contradict our conception.

13. Considering the whole of the geological and geophysical data available, we suggest to distinguish number of main structural elements within the Dnieper-Donetz depression. The zone of anticlinal (partly brachy-anticlinal and even dome-like) uplifts we establish along the line Priluki—Yazyny—Pozniaki—Chernukhi—Issachky—Mirgorod—Poltava in the direction of Grishino. This is our s o u t h e r n a n t i c l i n a l z o n e. Further northward t h e c e n t r a l a n t i c l i n a l z o n e follows, being sepa-

rated from the southern zone by a broad synclinal, proceeding along the line Dmitrovka—Talalaevka—Romny—Petrovskoye—Korulka and stretching further towards the main anticline of the Donetz basin. Still further in the north one more zone may be traced—the northern anticlinal zone (Akhtyrka—Izium—Krasny Oskol—Lissichansk). We do not know whether these zones of elevation are synchronous. They might have originated from the Hercynian movements, but they became definitely expressed only in result of the movements of the late Cimmerian phase. The Laramie folding and the previous Sub-Hercynian movements did not play any considerable rôle in the creation of major tectonic forms. These, as emphasized above, are folded structures, and the saline bodies viewed under this aspect should be considered not as independent formations, but rather as secondary ones, arising against the background of an already completed, complex tectonic structure.

14. To the above three tectonic units we may add one more structural element—a zone of marginal disturbances, inheriting the north-eastern border of the crystalline massif. This zone we establish along the line Kanev—Pivikha—Kalitva and across the Samara river to the southern border of the Donetz basin, covered by an exceptionally dense network of fractures and faults. A large fault at the Slovechny river, bounding the south Belorussia graben, continues this zone to the north-west. The disturbances characterizing the marginal zone are in part old, in part very young. The Quaternary age of the Kanev dislocations has been established long ago. The traces of certain disturbances of the Donetz basin, however, prove to be as young as the latter, this being attested by the admirable surface of the fracture with striae and slickensides in compact Quaternary (Pre-Rissian) loams of the watershed of the Tuzlovaya and Nagolnaya rivers; the direction of these striae and slickensides coincides with analogous slide planes in Carboniferous beds, which safely testifies to their community and synchroneity.

Institute of Geology.
Academy of Sciences of the Ukrainian SSR.

Received
28. XII. 1938.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

GENETICS

SCHEME OF THE CHEMICAL STRUCTURE OF CHROMOSOMES

By A. SHMUCK

(Communicated by N. I. Vavilov, Member of the Academy, 10. I. 1939)

Chromosomes play most prominent rôle in transmission of hereditary characters in living organisms, but as important as they are, their chemical structure is not yet definitely established.

Being observed at certain periods of their transformation to take characteristic coloration under the action of some reagents, chromosomes have been supposed by cytologists to contain thymo-nucleic acid.

Not the whole of the chromosome stains, however, where those reactions take place, at certain stages of transformations. Only in some constant and quite definite places, characteristic of the given chromosome, does colour appear. While they lie close to one another in one part of the chromosome, the coloured places exhibit a quite different picture in the other part, where large unstainable areas may be observed.

The linear arrangement in space of stainable points along the length of the chromosome is a strictly hereditary character, specific for each kind of organism.

If this arrangement be altered artificially, by intervention of X-rays for instance, there will result hereditary mutations in the organism, which on its further reproduction will show a new order in the succession of colourable points along the length of the chromosome.

If we were to take it for granted—what we have no reason to question—that these stainable points in the chromosome actually depend on the presence of nucleic acid, we should infer that the complex of factors keeping the acid in this arrangement is the fundamental mechanism which accounts for constancy of the organism's hereditary properties.

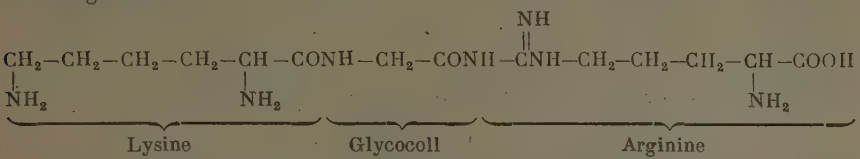
According to modern views of many cytologists ([1],[2]) there is a protein substance within the chromosome, which has the form of a highly polymeric molecule drawn out in length (called genoneme by N. K. Koltzov). Wrinch([3]) has found this protein substance to be composed chiefly of alkaline polyamino-acids.

The supposed presence of a linear polypeptide molecule within the chromosome is, in our opinion, quite sufficient basis to explain the characteristic and constant distribution of stainable points (nucleic acid) along the length of the chromosome, as well as the occurrence of slightly stainable regions.

Should indeed the genoneme be conceived as the gigantic linear chain of amino-acids linked to each other, we shall find alkaline groups NH_2

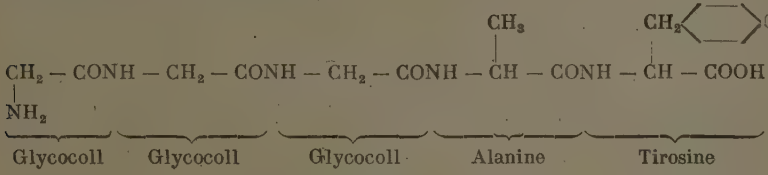
situated along this chain at different intervals from one another, their proportion being strictly determined by the chemical structure and position of individual amino-acids.

The following is an instance of the interaction between lysine, glycocoll and arginine:



Suppose that the addition of nucleic acid is possible only across the places of groups NH_2 with which it forms salt-like compounds, and it will be obvious that the position of these groups in the polypeptide chain or genoneme determines the stability of linear arrangement of chromiole portions in the chromosome, whereby the stainable points become situated in quite different parts of the latter, since in the case concerned the first chromiole group in the chain lies apart from the second at a distance of three atoms of carbon (about 4.62 Å), while seven atoms of carbon and three atoms of nitrogen (about 15.4 Å) make up the interval in the chain between the second and the third chromiole groups.

With polypeptide made of union between glycocoll, alanine and other amino-acids we can in general have no more that one group NH_2 in the chain, however long the latter may be:



Accordingly, no addition of nucleic acid and, hence, no formation of chromiole portions is possible along this part of polypeptide chain, which is fairly consistent with the presence of unstainable regions in the chromosome.

Thus, in case we suppose that the addition of chromatin substance (nucleic acid) goes across the places of basic primary amino-groups in the polypeptide chain, the above characteristic stability of successive linkage between different amino-acids will firmly fix those places along the length of the chromosome.

If we take the supposition advanced to interprete the irregular but strictly fixed arrangement of chromatin (nucleic) substances along the length of the chromosome, there arises naturally the question as to what is the responsible cause which makes this arrangement of amino-acids inheritable and why no new polypeptide chains with greatly varying relative position of primary amino-groups will form out of the complex set of individual amino-acids.

The answer seems to be given by the circumstance that salt-like compounds of the polypeptide chain, already available with the nucleic acid, strictly orientate the formation of new polypeptide chains in the cell. As nucleic acid is polybasic, its molecule, when bound in salt-like combination with one of the amino-groups of polypeptide chain, can at the same time and in the same form of linkage take up other primary amino-groups from the corresponding amino-acids of polypeptide chains.

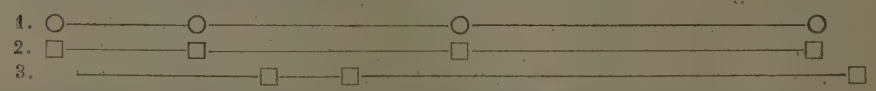
The reaction of multiple addition in linear molecules seems to depend greatly upon the relative linear position of the groups involved in the reaction and situated in another molecular chain.

In the case at hand, there should take place a special linear coincidence between the groups NH_2 in amino-acids or polypeptides and the free acid radicals of nucleic acid in the genoneme, and if therefore another polypeptide chain does completely coincide, in both composition and arrangement of amino-acids, with the genoneme, it will combine with the latter and this will correspond to the conjugation of chromosomes.

If, again, no such polypeptide chain as would be quite analogous to the genoneme of the given organism is availlable in the cell, we have to expect that more or less short and manifold chainlets, composed of individual amino-acids linked with one another, will add to the genoneme as soon as the linear distance berween NH_2-group has become equal to those between nucleic groups of the genoneme. It is likely to happen only when both structure and position of the amino-acids in those chainlets are quite identical. We thus find the peculiar structure of the genoneme, which is a linearly extended molecule consisting of salt arisen from the union of polypeptide with nucleic acid, to determine the specific and identical selection of amino-acids in the newly synthesized polypeptide chain. The peculiar protein chain in the chromosomes of the given organism reproduces itself and is as it were capable of multiplication by way of inheritance*.

No direct experimental evidence is as yet available in support of the conceptions here outlined, but then many cases are known where the linear arrangement of atomic groups in molecules has been found to determine the course of the chemical reaction. Thus, for instance, *o*-phtalic acid readily becomes anhydrous while *m*- and *p*-phtalic acids will never lose their water, whatever may be the conditions of the reaction. It is well known too that on formation of lactones and some other compounds the linear distance between the reacting groups is of prime importance. Furthermore, we can refer to the remarkable easiness with which monomeric cyclic ethers of glycocoll and oxalic acid are apt to form in face of the great difficulty of formation of such ethers with dicarbonic acids, which have a longer carbon chain.

When the reaction of mutual addition proceeds in one point of the molecule, the reciprocal spatial orientation of molecules matters little. But as soon as molecular chains react in several points (atomic groups)—and this is the case with our examples—the reciprocal orientation of molecules proves of exceptional importance.



1. Genoneme; places of addition of nucleic acid denoted with circles.
2. Polypeptide chains; position of NH_2-groups denoted with squares. Addition is possible.
3. Polypeptide chain; position of NH_2-groups denoted with squares. No addition is possible.

The fact that the reaction of addition will not go on unless strict reciprocal orientation of reacting groups, with reference both to one and three

* What has been set forth here, is nothing but a general outline which can by no means be considered as corresponding strictly to the structure of chromosome. Very likely the chromiole regions are due to many closely situated groups NH_2, rather than to one such group, and the intervals between the regions may possibly be occupied by many amino-acids lacking free NH_2-groups.

dimensions, is available, must not only be taken into account for the inheritable stability of the chemical structure of chromosomes, but it can also successfully serve as a basis for explaining a number of specific biochemical processes and among them of those, by whose means individual proteins are built up in the given organism when the latter is nourished with various amino-acids etc.

The specific stability of structure of the polypeptide chain, in face of the diverse character of its making-up functional groups, being transmitted from cell to cell and from parent to progeny, should result in a nearly constant run of fundamental chemical reactions proceeding in cells and, hence, in the invariability of final products of those reactions. This gives us an idea of the material factors of heredity.

The constant arrangement of individual functional groups [CO; NH; OH; $C_6H_5(OH)$, etc.] along the length of the genoneme, as well as their reciprocal positions and intervals, do however not determine the further constancy of chemical processes in the cells, without formation in the latter of chemical substances indispensable for those reactions to take place.

The structure of genoneme here described must suffice, according to our conception, for explaining the steady course of chemical processes in the cell, as well as the constancy of these related forms and properties of the organism, and we need not recur in this explanation to special «genes».

As the functional groups in the genoneme lie between nucleic and chromiole disks, we believe that these intervals, more than the disks themselves, directly participate in further reactions proceeding in the cells.

On the basis of our assumptions, we can foresee that in some regions of the genoneme such intervals between two NH_2-groups may possibly occur, as can be substituted with chainlets of amino-acids of different chemical structure but equal length, as measured between the two groups in question. In that case the difference of functional groups will result in mutational changes of the course of chemical reactions in cells and call forth mutations in the organism.

In some cases such substitution seems to occur with exceptional ease (substitution of alanine by serine, of leucine by isoleucine, etc.) and with these regions of the genoneme we have therefore what is called by the geneticists the mutable regions of chromosomes.

We are thus entitled to say that mutations in organism are determined either by the change in the composition and arrangement of amino-acids in polypeptide chains of chromosomes, or by formation in cells of such amino-acid chainlets adding to the genoneme, as differ in composition but equal in the linear distance between NH_2-groups, compared to separate portions of the typical polypeptide chain of the chromosome.

Institute of Genetics.
Academy of Sciences of the USSR.
Moscow.

Received
10. I. 1939.

REFERENCES

[1] Н. К. Кольцов, Организация клетки (1936); Биолог. журн., 7 (1938). [2] Goldschmidt, Physiol. Genetics (1938). [3] Wrinch, Protoplasma, XXV, 550 (1936).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

GENETICS

STUDIES IN DEVELOPMENT GENETICS

SENSITIVE PERIODS AND THEIR RELATION TO THE PROBLEM OF THE MECHANISM OF GENE ACTION IN DEVELOPMENT

By N. N. MEDVEDEV

(Communicated by N. I. Vavilov, Member of the Academy, 4. I. 1939)

It was shown by the author in his preceding communication ([3]) that in about 50% out of the thirty cases studied, lethal point mutations in *Drosophila melanogaster* cause the death of lethal zygotes at the pupal stage of development. In the remaining 50% of cases the lethal genes studied exert their influence at earlier stages, i. e. at the larval or even at the embryonic (egg) periods of development.

The moment of pupation, with regard to which the lethal strains under consideration have been provisorily classified, divides the whole cycle of development into two nearly equal periods ([2]).

In this connexion it seemed of interest to dwell in more detail on the question whether in the development of *Drosophila melanogaster* there are any particular or sensitive periods, at which the disturbance of normal processes of development preferably or even exclusively takes place. On the other hand, one may assume that there exists no dependence of the type just mentioned, and that breaking down of the developmental processes takes place at any stage, its frequency being distributed more or less at random throughout the period of development. So far as in a large number of cases it is possible to connect the influences caused by lethal genes with definite morphological changes and abnormalities, it seems obvious that the methods of investigation of a number of important problems of developmental genetics to be applied in the future will depend upon the solution of this alternative.

The present communication is devoted to a brief description of the results of experiments carried out with the aim to determine the stages at which lethal genes with early expression exert their influence.

The author is very much indebted to I. K. Schmidt for her able assistance throughout the experiments.

Material and Methods

As mentioned above ([3]), the egg and larval lethal mutants were used as material for the present investigation. The stocks, twelve in number,

were selected in the preceding experiments from the collection of lethal stocks kindly placed at my disposal by W. W. Sakharov.

In order to differentiate the egg lethals from the larval ones, the larvae from the stocks under investigation were first analyzed with regard to the moment of their hatching. The method consisted in counting the number of eggs laid by females from a given stock (in a number of tests), and in comparing it with the number of eggs which failed to develop. Since 25% out of the total number of zygotes, being homozygous for the lethal gene, are incapable of development, the comparison of the number of eggs laid with that of the undeveloped eggs gives a direct answer to the question as to whether the dying out of the lethal zygotes takes place at the embryonic or at the larval period of development. In order to facilitate the procedure of counting eggs, Spencer's method was used (4). The results of this part of the work are given in Table 1.

The next step of the investigation consisted in a more exact determination of the stage of dying out of the lethal larvae.

Just as in the Ist series of experiments (3), the X-chromosome $y\,sc^8\,w^a\,lz^s\,\delta\,49$ was used as a marker and at the same time as a balancer. Owing to the presence in this chromosome of the gene for yellow body colour, grey lethal male larvae (Table 2, column 3 and 7) could be easily and unmistakably identified and isolated from those of the other types at any instar (from the viable males $y\,sc^8\,w^a\,lz^s\,\delta$ 49—Table 2, column 4 and 6, by the colour of the mouth armature and some other characters; from both types of female larvae—Table 2, column 2 and 5, by the size of gonads).

Table 1

Data on the Analysis of Stages at Which Dying Out of Lethal Larvae Occurs

No of stocks *	Number of eggs laid	Number of eggs not developed	Eggs not developed in %	Stage at which dying out of lethal male larvae takes place
1	2	3	4	5
K-10	3023	101	3.3	Larva
K-52	1266	29	2.2	»
MX-1	2481	56	2.2	»
MX-7	1588	365	23.0	Egg
K-45	1910	71	3.7	Larva
K-48	1286	47	3.6	»
K-49	2359	582	24.6	Egg
K-60	1139	46	4.0	Larva
K-61	1200	19	1.5	»
K-3	1665	72	4.3	»
K-4	2358	90	3.8	»
K-8	2725	71	2.6	»
Wild type (Berlin)	1089	24	2.2	Control

* There is given in Tables 1 and 2 the original numeration of stocks by W. W. Sacharov (3).

It is known that larvae of *Drosophila melanogaster* pass in succession the first, second and third instars, which are separated from each other by the first and second molt respectively. Since the larvae of different instars are readily distinguished from each other by a number of fairly noticeable morphological peculiarities (1), the determination of instars of a given larva offers no difficulties. The results of this part of analysis are given in Table 2.

Table 2

Data on the Analysis of Instars at Which Dying Out of Lethal Larvae Occurs

No of stocks	Kinds of larvae found in the stock throughout the II and III instars						Instar at which dying out of lethal male larvae takes place
	II instar			III instar			
	grey larvae		yellow larvae	♀♀	♂♂		
	♀♀	♂			yellow	grey	
1	2	3	4	5	6	7	8
K-10 . . .	49 (47)*	83 (—)	81 (65)	143 (114)	77 (64)	—	II
K-52 . . .	59 (56)	—	94 (76)	74 (67)	33 (25)	—	I
MX-1 . . .	50 (48)	—	75 (68)	161 (135)	79 (69)	—	I
K-45 . . .	27 (26)	—	92 (77)	98 (88)	25 (25)	—	I
K-48 . . .	22 (21)	—	53 (41)	158 (148)	64 (59)	—	I
K-60 . . .	166 (141)	—	228 (152)	11 (10)	2 (2)	—	I
K-61 . . .	45 (42)	—	70 (56)	31 (31)	10 (7)	—	I
K-3 . . .	68 (60)	—	96 (76)	31 (30)	5 (4)	—	I
K-4 . . .	152 (145)	—	248 (208)	114 (97)	50 (41)	—	I
K-8 . . .	118 (110)	—	149 (126)	85 (67)	71 (63)	—	I
Wild type (Berlin) .	50 (46)	50 (48)	—	50 (48)**	—	50 (49)	Control

* In brackets—the number of flies hatched. ** Grey ♀♀ only.

Results Obtained and Conclusions

The results obtained and the conclusions arrived at may be briefly summarized as follows:

1. In two cases out of the twelve studied dying out of unviable zygotes takes place at the embryonic (egg) period of development (Table 1).

2. In nine cases out of the total number of the stocks studied dying out of unviable male zygotes occurs at the first instar, i. e. between the emergence of larvae from eggs and their first molting (Table 2).

3. Only in one case out of the twelve strains studied the lethal effect is observed during the second instar, i. e. between the first and the second molting (Table 2).

4. In addition to these two there is still one period in larval development when dying out of lethal larvae takes place in a rather large number of cases. This period is closely connected with puparium formation. Mortality of lethal larvae at this stage of development was observed in five strains out of the thirty studied (these stocks are not included in Tables 1 and 2).

5. The data referred to above permit of concluding that in the development of *Drosophila melanogaster* there actually exist sensitive periods at

which the developmental processes are intimately influenced by the action of lethal genes.

One of these sensitive periods seems to coincide with the embryonic development. The data on hand show, however, that in a large number of stocks studied lethal zygotes prove able to pass embryonic development and to continue development to rather advanced stages.

The other two sensitive periods are: the first instar and the period closely connected with pupation. Both of them are characterized by more strong expression. It is possible to connect these sensitive periods with definite developmental processes and thus to approach the solution of a number of problems bearing upon the nature of processes which are effected by lethal genes.

Institute of Genetics.
Academy of Sciences of the USSR.
Moscow.

Received
7. I. 1939.

REFERENCES

[1] W. W. Alpatow, Jrnl. Exper. Zool., **52** (1929). [2] N. N. Medvedev, ZS. f. indukt. Abst. u. Vererbgsl., **70** (1935). [3] N. N. Medvedev, C. R. Acad. Sci. URSS, XX, 319—322 (1938). [4] W. P. Spencer, Science, **85**, № 2203, 298 (1937).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

GENETICS

PRODUCTION OF POLYPLOID PLANTS

HAPLOID AND TRIPLOIDS IN *PRUNUS PERSICA*

By G. D. PRATASSENJA

(Communicated by N. I. Vavilov, Member of the Academy, 8. I. 1939)

It was established by an investigation of flower buds of different varieties of peaches at the tetrad stage that frequent falling out of the reduction division and the formation of two-celled «tetrads» with diploid nuclei are common(5). Comparatively large pollen grains develop from cells with diploid nuclei. Selection of this large pollen and experimental pollination with it of flowers of peach tree triploid seedlings were produced(4). The study of varieties of peach with respect to the occurrence of two-celled «tetrads» in flower buds continued also during 1938. One hundred and fifty additional varieties of peaches were studied. Varieties were found which possessed a large proportion of non-reduced gametes (Khidistavsky No 23 contains from 12.81 to 35.98% in different individual trees; New Prolific—19.65%, etc.). In the course of the investigation of the tetrad stage in the variety J.H. Hale, cells were observed which contained up to eight (and even more) nuclei enclosed in a common maternal wall. The occurrence closely reminded the octads observed in the course of investigation of the reduction division in the amphidiploid *Nicotiana rustica*×*N. tabacum*(2); the sole minor differences consisted in the fact that no formation of partition walls between the nuclei enclosed in the maternal wall was at first observed here. Further study of earlier stages of sporogenesis in this variety has established that no formation of the partition wall takes place at the last somatic division which immediately precedes the reduction division. The growth of the resulting binucleate pollen mother cells proceeds under this condition. Accordingly, during the heterotypic division rather elongated cells, as if formed of two cells sticking together, are found; in some instances one may even observe vestigial partition wall in these «twin cells».

The double cells may be of various sizes at the time of the reduction division of the mother pollen cells.

In such cells the first and the second reduction division take place in each nucleus independently. At the tetrad stage in most cases eight-nucleate cells are observed instead of the usual cells containing fours of nuclei. The nuclei of the eight-nucleate cells are smaller than those of the normal four-nucleate ones. During the separation of the tetrad into pollen grains all the many-nucleate cells lie behind in this process of separation. At the time of flowering nearly whole of the pollen is aborted in this variety. However,

trees of this variety, when they are in the vicinity of trees of other varieties which produce good pollen, set fruits well and produce normally developed seeds. In the variety J. H. Hale the sporogenous tissue of the anthers degenerate, and the sporogenous tissue of the ovaries develops normally. The degeneration of the sporogenous tissue begins prior to reduction division, i. e. during somatic divisions in the anthers.

Selection of large pollen grains was done by the method described previously(4), and certain varieties of peaches were pollinated with the selected large pollen. The results of pollination are presented in Table 1.

Table 1

Varieties	Number of flowers pollinated	Number of fruits formed	Number of fruits harvested	Number of seeds produced	Number of seedlings growing	Number of plants with somatic chromosome number equal to		
						8 (2 n)	16 (2 n)	24 (2 n)
Elberta × Fitzgerald	160	5	5	4	3	—	3	—
» × New Prolific	152	17	12	9	9	—	5	4
La France × K. Olga	124	4	4	3	3	—	3	—
» » × N. Prolific	66	3	2	2	2	—	1	1
» » × Téton de Vénus	130	1	1	1	1	—	—	1
Zolotoj Yubilej × K. Olga	64	3	3	2	0	—	—	—
J. H. Hale × Téton de Vénus	33	2	1	1	1	—	—	1
Kushnarev × Foster	45	1	1	0	—	—	—	—
» × Téton de Vénus	60	2	1	2	0	—	—	—
New Prolific × N. Prolific	79	5	4	3	4	1	3*	—
Triumph × N. Prolific	78	4	3	2	0	—	—	—
» × Fitzgerald	211	10	10	1	0	—	—	—

* One of the seedlings represents a chromosomal chimera.

Aside from crosses presented in Table 1, pollinations were made with selected large pollen La France × Fitzgerald (81 flowers) and Grinsborough × Téton de Vénus (64 flowers); however, no fruits were obtained from them.

One may see from Table 1 that the proportion of flowers which developed seeds after pollination with large pollen was rather low. In two cases as a result of pollination with large pollen «twin seeds» containing two embryos enclosed in a common seed-coat were obtained. In the cross Kushnarev × × Téton de Vénus the twins were underdeveloped and highly malformed. These embryos started development after having been placed on sterile filter paper in a Petri dish, but very soon died. From a 1937 cross of this combination a triploid peach plant was obtained (4). In case of pollination of a tree with its own selected large pollen (New Prolific × New Prolific) the twins produced proved to be viable; their roots were fixed and cytological analysis was made.

It should be noted that the twin-embryos New Prolific × New Prolific enclosed within a common seed-coat were of different size. The seed which contained them when taken out of the pit did not differ externally from the other seeds; only when the seed-coat and the perisperm were removed, it was possible to see peculiar transverse and longitudinal folds on the embryo. On the second day after the embryo was placed on wet filter paper, swelling separated the two embryos along the transverse fold. The embryo located nearer to the micropyle (at the place where the root-tip is usually found) was

very small and comprised approximately one quarter of the larger embryo. Besides, the cotyledons of the smaller embryo were unequal both in size and shape. The larger embryo started growing on the fourth day after having been placed on the wet filter paper in a Petri dish at room temperature, while the smaller one which was placed in the same Petri dish started growing only on the sixth day. On the third day following germination the embryos were planted into pots with sand; after some time they were transplanted to pots with usual slightly fertilized soil. Prior to transplantation from sand to normal soil these seedlings were photographed. It may be seen from the photograph presented in Fig. 1 that they differ in growth. The seedling from the larger embryo grows faster than that from the smaller one.

Fig. 1. Two seedlings of the peach (twins): *a*, $2n=16$ chromosomes; *b*, $2n=8$ chromosomes.

Fig. 2. Somatic plates of the seedlings of the peach: *a*, haploid; *b* and *d*, chromosomal chimera; *c*, triploid.

The analysis of the cell divisions in the rootlets of these «twins» established the fact that the seedlings which came from the smaller embryo contain only eight chromosomes, i. e. its chromosome number is equal to the reduced number of the gametes of peaches. The existence of a plant of the variety New Prolific possessing a haploid chromosome number in somatic cells was thus established (Fig. 2, *a*). Upon the change of this plant to diploid condition one will be able to produce a pure «homozygous» form of peach.

In the majority of cells of the seedling growing from the larger embryo 16 chromosomes could be counted at nuclear divisions; however, in one rootlet of this plant a sector was found whose cells contained 32 chromosomes (Fig. 2, *d*). It was established in this instance that a chromosomally chimeral plant composed of sectors with 16 and 32 chromosomes was developing from the larger embryo.

Fig. 3.

Besides, as may be seen from Table 1, as a result of pollination with large pollen a number of peach-plants were obtained which contained in their somatic cell 24 chromosomes, i. e. which are triploid.

It should be noted that not all the chromosomes of the haploid occupy at the metaphase of nuclear division one equatorial plane, but, instead, one or two of them are out of this plane; the phenomenon is similar to that emphasized by many authors for the reduction division.

Leaves were taken from the seedlings of the haploid, diploid and triploid peaches (those of equal age were selected) in order to study the size of the stomata in connexion with different chromosome numbers in the cells of these plants. The data obtained from measurements of the length and width of the stomata are contained in Table 2. The figures of Table 2 were treated by the method of sums.

Table 2

Varieties	Chromosome number = $2n$	Number of stomata measured	Length of the stomata			Width of the stomata			$M_1 \times M_2$	Ratio of the areas of the stomata
			M_1	$\pm m$	σ	M_2	$\pm m$	σ		
New Prolific × × N. Prolific	8	125	4.54	0.04	0.46	3.61	0.03	0.33	16.28	1
Do	16	125	5.49	0.04	0.47	4.23	0.03	0.36	23.22	1.42
Elberta × New Prolific	16	125	5.45	0.05	0.63	4.01	0.03	0.37	21.85	1.34
Do	24	125	6.1	0.05	0.52	4.45	0.03	0.38	27.15	1.77

Note. The values of the length and width are expressed in divisions of the ocular micrometer.

As may be seen from the table, the ratio of the approximate areas of the stomata (obtained by multiplying length by width) of the haploid ($2n$ = =8) and diploid ($2n$=16) is equal to 1 : 1.42. These data approximate very closely those by Zhurbin [1] on the ratio of the area of the stomata of the diploid *N. glauca* to that of the autotetraploid of *N. glauca*. As to the ratio of the area of stomata of the diploid ($2n$=16) peach to that of the triploid ($2n$=24), it equals 27.15 : 21.85=1 : 1.2, i. e. is precisely equal to the ratio between the stomata of the diploid *N. glauca* and that of the triploid *N. glauca* which was given in the above cited paper by Zhurbin.

Cytological Laboratory.
Nikitsky Botanical Garden.
Yalta.

Received
11. I. 1939.

REFERENCES

[1] A. Zhurbin, C. R. Acad. Sci. URSS, XVIII, № 7, 465—468 (1938). [2] A. Kasparyan, ibid., XX, № 1, 53—56 (1938). [3] Г. Д. Пратасеня, Тр. Гос. Никитск. бот. сада, XIX, вып. 1 (1935). [4] G. D. Pratassenja a. E. M. Trubitzina, C. R. Acad. Sci. URSS, XIX, № 6, 351—353 (1938). [5] F. Kobel, Arch. d. Jul. Klaus-Stift. f. Vererb., III, H. 1, 1—84 (1927).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

GENETICS

ON THE OCCURRENCE OF FACULTATIVE PSEUDOGAMY IN A TRIPLOID VARIETY OF RASPBERRIES, IMMER TRAGENDE (*R. IDAEUS*)

By D. F. PETROV

(Communicated by N. I. Vavilov, Member of the Academy, 8. I. 1939)

In this paper will be reported some data on facultative pseudogamy which was discovered by us in the triploid variety of raspberries, Immer tragende.

The study of microsporogenesis has shown that from 2 to 3 trivalents, from 4 to 5 bivalents and from 4 to 5 univalents are on the average formed at the diakinesis and heterotypic metaphase. In heterotypic anaphase bivalents divide regularly, while the separation of trivalents and the passing toward the poles of univalents are irregular, owing to the fact the daughter nuclei at the heterotypic metaphase possess chromosome numbers from 7 to 14, cells with 10—11 chromosomes being the most common ones.

The majority of pollen grains which received aneuploid chromosome numbers probably degenerate; the high proportion of aborted pollen noted in Immer tragende (up to 90%) is caused by this fact.

Embryological study has shown that a mature embryo-sack contains a normal nuclear apparatus; unfortunately, however, the process of meiosis and macrosporogenesis, as well as the early stages of the development of the embryo sack, could not be traced as yet.

The variety Immer tragende yields abundantly when open pollinated; on the other hand, it proved wholly sterile when emasculated and isolated.

In 1934 emasculated flowers of Immer tragende were pollinated with the pollen of variety Malborough (*R. idaeus*, $2n=14$); several plants were obtained from this cross, two of which bloomed in 1936. They were wholly fertile and proved exactly identical with the maternal plant. Chromosome counts reveiled in rootlets of the two plants 21 chromosomes. The behaviour of the chromosomes in meiosis in these plants was of the same type, as in the original plants Immer tragende.

In 1937 crossing of Immer tragende × Malborough was repeated and from seeds produced by this cross some tens of plants were raised in 1938; all of them were matroklinous like plants obtained in 1935. In 8 of these plants which were studied cytologically the chromosome number proved to be equal to 21.

It is thus evident that in the crosses between Immer tragende and the diploid variety Malborough takes place the typical phenomenon of pseudogamy.

An entirely different situation is observed when Immer tragende is crossed with hexaploid dewberries, in particular with the Michurin's variety «Texas» (*R. loganobaccus*, $2n=42$).

Emasculated flowers of Immer tragende were pollinated in 1935 with pollen of «Texas». In 1936 10 plants were obtained from seeds of this cross; they were true hybrids, beyond any doubt, and resembled externally the male parent «Texas» more than Immer tragende. Cytological examination of 6 of these plants performed in 1938 has shown that their somatic chromosome number was equal to 42.

In 1937 repeated crossing of Immer tragende with «Texas» was made. In 1938 from seeds produced 57 plants were raised; all of them were undoubtedly hybrids. Chromosome counts made in 10 of these plants have shown that in all the plants studied cytologically the chromosome number was equal to 42. We thus obtained as a rule true hybrids from crosses between Immer tragende and the hexaploid variety of dewberries «Texas».

Quite a number of cases of apogamy and pseudogamy ([1]) are known at present; according to literary evidence, the unreduced «egg-cells» of obligatory apomictic forms appear to be incapable of fertilization.

In other cases, for example in *Hieracium*([2]) where apomixis is of facultative type, usually two kinds of «egg-cells» are present, viz., with haploid and diploid chromosome number; the former develop after a normal fertilization and produce true hybrids, while the latter develop without fertilization ([3]).

There are exceptions, it is true; thus, specialized unreduced «egg-cells» sometimes develop as a result of fertilization and highly polyploid hybrids are produced in such cases. As an example may be cited the case of production of two hybrid tetraploids in the progeny of the apomictic triploid variety of apples, *Malus hupehensis*, as described by Dermen([4]). However, such cases are of exceptional and, besides, of rather rare occurrence; the rule is the apomictic development of unreduced «egg-cells», and the above described results represent the first instance of the mass production of hybrids from unreduced «egg-cells» which, as a rule, develop apomictially.

Lack of data bearing upon the early stages of embryo-sack development unfortunately still prevents to find out the real cause responsible for the diploid chromosome number in the functional «egg-cells» in Immer tragende. We thus still are at fault whether in this case we have to do with a failure of heterotypic division (in meiosis), resulting in the formation of true «egg-cells» with unreduced chromosome numbers, or with an additional embryo-sack developing of some somatic tissues.

To make this problem clear further embryological studies are necessary; for the time being it is still unsolved.

Received
11. I. 1939.

REFERENCES

[1] O. Rosenberg, Handbuch d. Vererbungswiss., **12**, 1—66 (1930). [2] C. M. Ostenfeld, ZS. f. ind. Abstamm. u. Vererb., III, 241—285 (1910) [3] A. Gustavson, Hereditas, **21**, H. 1, 1—112 (1935). [4] H. Dermon, Jrnl. of the Arnold Arboretum, XVII, 90—105 (1936).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

GENETICS

POLYPLOIDS IN RYE INDUCED BY X-RAYS

By L. BRESLAVETZ

(Communicated by N. I. Vavilov, Member of the Academy, 25.XII.1938)

Geneticists became recently very much interested in the production of polyploid plants through the action of colchicine and acenaphthene. However, the excellent results obtained abroad (Blakeslee and Avery) as well as by our geneticists (Kostoff, Karpechenko, Lutkov and others) do not dismiss the possibility of producing polyploids in other ways.

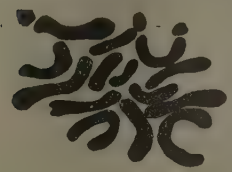


Fig. 1. Nuclear plate in the cell of the rootlet of the control plant No 3.
All the drawings were made with the aid of the camera lucida of Abbé. Fig. 1 and 2 were made with eyepiece 20 and objective 120. All the rest were made with eyepiece 20 and objective 90.

Our previous investigations (Breslavetz and Afanassieva) have shown that the action of various dosages of X-rays upon the seeds and seedlings of rye cause the appearance of polyploid cells in the tissue of the roots. The number of such cells may be insignificant in some roots (1—2 cells per root), while in other cases entire sectors of polyploid cells are observed. One of the authors was able to find, besides, by means of mass-fixation two roots composed exclusively of hexaploid cells.

These cytological investigations on the X-rayed rye enabled us to anticipate the possibility of producing polyploids in rye by means of irradiation of this sort. We have selected the dosage of 250 *r* for the treatment of seedlings, for it was just this dosage to which the plants answered by showing most intracellular alterations.

In the autumn of 1936 over 500 seedlings of the rye «Viatka» were subjected to irradiation after which they were planted in ordinary pots, one per pot; 20 control plants which were in the same stage of development were planted simultaneously. Following individual fixation of rootlets of X-rayed plants and of the control all the plants were transplanted to the free ground. During winter a certain proportion of plants in the two groups died; the rootlets of those plants which survived were subjected to cytological investigation.

None of the 16 control plants which survived proved to contain polyploid cell; on the other hand, among 533 X-rayed plants two (No 33 and 187) proved to be tetraploid. Besides this, in the majority of the X-rayed plants there were observed numerous chromosome alterations which are to be described in the next paper.

The majority of rye plants notably contain in their cells 14 chromosomes. One of such 14-chromosome plants is shown on the drawing (Fig. 1). We find

it superflous to dwell upon the morphological description of the chromosomes which was worked out in detail by other authors (Levitsky, Shmargon and others). Let us pass to the chromosome plate of the X-rayed plant No 33 (Fig. 2); counting of the chromosomes of this plate leaves no doubt as to the doubling of the chromosome number.

Careful examination of all the cells of three rootlets of the plant No 33 and of two rootlets of

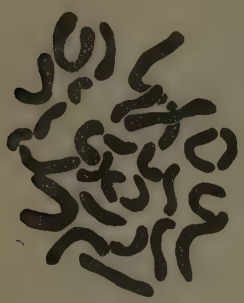


Fig. 2. Nuclear plate in the cell of the rootlet of the tetraploid No 33.

Fig. 3. Resting cell of the control plant No 3.

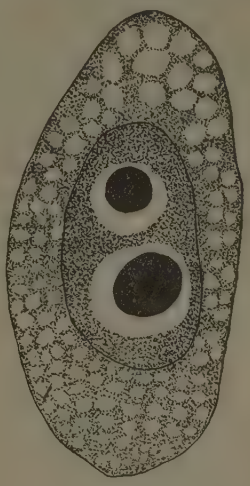


Fig. 4. Resting cell of the tetraploid No 33 under the same magnification.

the plant № 187 has shown that all the plants contain exclusively 28 chromosomes. The more numerous chromosomes occupy a considerably larger space than the 14 chromosomes of the control plant do; this may be seen from the comparison of the above two figures.

The size of the cells of the tetraploid rootlets is increased according to the chromosome number; this is expressed both at metaphase and at the resting stage (Fig. 3 and 4). It is known

Fig. 5. Nucleus of a tetraploid cell with three nucleoli.

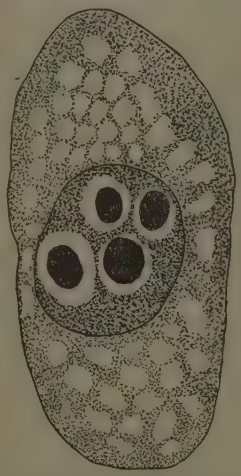


Fig. 6. Nucleous of a tetraploid cell with four nucleoli.

from literature that not only the number of the chromosomes, but the number and behaviour of the nucleoli betray polyploids. Presence of two nucleoli is typical of the resting cells of diploid rye (Fig. 3). In polyploid cells two nucleoli are seen only at the end of the resting stage (Fig. 4),

while in younger nuclei there are 3—4 nucleoli (Fig. 5 and 6) which fuse with each other in different ways and thus produce peculiar shapes typical of polyploid cells.

It was noted above that tetraploid cells and nuclei are larger than the diploid ones. In order to check these observations we have made measurements of the diameters of the rootlets, of the two diameters of cells and of the two diameters of nuclei in two control plants and in two tetraploid plants. Each mean value contained in the table had been deduced from 20 measurements in plants No 12 and 187 and from 30 measurements in plants № 3 and 33. Measurements were made with the aid of the ocular micrometer; identical regions of the roots, identical tissues and cell layers were selected for the measurements. Rootlets were measured with the eyepiece 20 and object glass 10 (the value of each division of the ocular micrometer was equal to 10 microns). The diameters of the cells and nuclei were measured with the eyepiece 20 and object glass 90 (the value of a division was equal to 1.25 micron).

Table 1

Diameters

Plant No	Rootlets	Cells		Nuclei	
		Longitudinal	Transverse	Longitudinal	Transverse
Control No 3	33.9±3.69	23.6±0.64	19.0±0.49	8.9±0.20	9.0±0.20
Control No 12 . . .	27.2±2.12	27.5±1.01	19.1±0.22	10.2±0.29	9.8±0.20
Tetraploid No 33 . .	38.5±3.91	32.3±0.75	24.7±0.64	14.2±0.54	13.3±0.54
Tetraploid No 187 .	35.5±3.28	30.2±0.82	24.2±0.50	12.4±1.70	11.3±0.34

A detailed study of this table shows that there exist differences between the two control plants, as well as between the two tetraploid plants in respect to all the five indices; however, the differences between diploids and tetraploids are considerably greater.

When mean values for the two control plants are compared with those for the two polyploid plants, as shown in Table 2, one may see that the diameter of the rootlets in the one polyploid (No 33) is increased 28.3%, while the corresponding figure for the other is only 18.3%; similarly, the longitudinal diameter of the cells is increased in the one by 31.9% and in the other by 26.6%. The difference is especially great in the longitudinal diameters of the nuclei which are increased in the first polyploid by 42.1% and in the second one by 30.5%.

Table 2

Increase in Diameters (in %)

Plant No	Rootlets	Cells		Nuclei	
		Longitudinal	Transverse	Longitudinal	Transverse
33	28.3	31.9	30.0	42.1	41.5
187	18.3	26.6	26.7	30.5	20.0

Notwithstanding the fact that there are differences between the two tetraploids, we can witness an increase in all the indices as compared with the control plants.

Usually the size of the pollen is also increased in tetraploid; this character facilitates identification of polyploids both under natural conditions and in experiments. We have measured pollen in the control and in the X-rayed plants; however, the second tetraploid proved not to be included here.

Comparison of the diameters of the pollen grains of the control plant No 3 and of the tetraploid No 33 shows statistically wholly significant differences.

Table 3

Sizes of the Pollen Grains

Plant No	Diameter	Difference	$\pm m_{diff}$
Control No 3	14.0±0.1	3.84	0.067
No 33	17.84±0.16		

Summing up, we may regard our two plants as tetraploids on the basis of direct chromosome counts and of indirect evidence as well, viz., increase of the number of nucleoli, especially of their shape, increase of the diameters of cells, of nucleoli and of pollen grains.

The following considerations have led us to the assumption that the action of X-rays has produced them:

1. Repeated investigations of a great number of rootlets of rye have never discovered polyploids.

2. Aside from these rootlets which were tetraploid throughout, we have observed in the rootlets of 83 plants both single and numerous polyploid cells; the series thus extends from rootlets containing one or two polyploid cells to those which are tetraploid throughout.

Institute of Genetics.
Academy of Sciences of the USSR.

Received
25. XII. 1938.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

EVOLUTIONARY MORPHOLOGY

DOMINANCE AND SELECTION

By M. M. KAMSHILOV

(Communicated by I. I. Schmalhausen, Member of the Academy, 14. I. 1939)

After the publication of Fisher's article ([2]) problems of the evolution of dominance have been widely discussed in the biological literature. It be sufficient to mention the works by Wright ([16], [17]), Haldane ([8]), Muller ([19]), Harland ([9], [10]) and by Fischer himself ([2], [3], [4], [5]).

In the USSR the problem of dominance is being lively discussed in connexion with the works by Michurin ([13]) and Lyssenko ([12]). Most authors agree as to the evolutionary origin of dominance, though individual conceptions of the mechanism of the process vary. Direct selection experiments assume great significance in solving the problem of the mechanism of evolution of dominance.

Payne (1918) carried out selection for the increase of the number of scutellar bristles in *D. melanogaster*. The increased number of bristles as a result of selection was dominant over the normal one [quoted from Goodal ([7])].

Timofeev-Ressovsky ([15]), who has conducted in a line of *Drosophila funebris* selection for a maximum expression of mutation of radius incomplectus, obtained partial dominance of this character over the normal one. He considers dominance as being correlated with strength of expression. Similar data were obtained by Stanley ([14]) for the mutation vestigial in *D. melanogaster*. In the practice of cattle breeding are known cases of dominance of the finer quality of merino wool, of an increased milk production and the like, i. e. of such characters for which selection has been performed for years ([1]).

There seems to exist a strong correlation between the expression of a character in homo- and heterozygous condition ([6]). Modifiers, whose presence causes the increase of expression in a homozygote, simultaneously increase the expression in a heterozygote. Consequently, selection for intensified expression results in an increased dominance of the character.

In nature and in agricultural practice organisms possessing particular characters are selected. Direct selection for characters is the basic type of selection. Evolution of dominance must be apparently a result of this direct selection.

The purpose of the present work is to find out how direct selection for maximum or minimum expression of a given character would affect the modification of its dominance.

As material for the present investigation, different lines of eyeless *D. melanogaster* were used, after they had been subjected to selection for a maximum expression of the character (+lines), as well as a minimum expression of the character (—lines), and lines which had not been subjected to selection

(*N*-lines). Neutral lines, which were known to be unselected for the character under investigation, are of particular importance in the analysis. The absence of crossing with similar lines reduces greatly the value of the experimental data given before. As +lines were chosen lines *N1A* and U_2, displaying a corresponding average expression of eyeless 94.75% and 90.5%. As a —line was used line No 6 which has been reared in the laboratory in mass cultures over a period of more than 7 years and is exhibiting an average occurrence of eyeless 1.5%.

Neutral lines were derived as a result of the introduction into the Samarkand and the Berlin lines of *D. melanogaster* of a fourth chromosome with the gene eyeless from line No 6. By means of a special method of supressors the remaining chromosomes have been kept intact. In other words, in these lines (*C* and *B*) the mutation eyeless was introduced into a genotype, which had not been subjected to selection for a maximum or minimum expression of eyeless.

The method of calculation of the expression of eyeless in per cent is described in the work of Kamshilov ([11]). The following crosses have been carried out:

1. +lines *N1A* and U_2 (females) were mated with neutral lines *C* and *B* (males).
2. —line No 6 (females) was crossed with neutral lines *C* and *B* (males).
3. + line *N1A* (females) was crossed with—line No 6 (males).

Lines	Number of flies	Expression of eyeless in %	Theoretically computed % of expression	Error of the difference	Significance of difference	Zeleny's coefficient of dominance
N1A	216	94.75±1.4	—	—	—	—
U_2	192	90.5 ±1.53	—	—	—	—
№ 6	440	1.5 ±0.43	—	—	—	—
C	1205	41.25±1.2	—	—	—	—
B	383	57.5 ±2.03	—	—	—	—
C×*N1A*	961	74.0 ±1.27	68	2.24	+2.68	0.612
C×U_2	942	81.0 ±1.14	65.8	2.25	+6.76	0.807
B×*N1A*	508	76.5 ±1.7	76.1	2.95	+0.13	0.51
B×U_2	408	77.5 ±1.72	74	3.06	+1.14	0.606
C×№ 6	950	14.9 ±0.95	21.4	1.59	—4.08	0.664
B×№6	242	17.75±2.04	29.5	2.85	—4.12	0.71
N1A×№ 6	578	44.25±1.52	48.12	2.11	—1.83	—

At the same time lines *N1A*, U_2, *C*, *B*, No 6 were started for comparison.

Each culture was examined thrice—on the 3rd, 6th and 9th day after hatching. In the table are summarized data on all three counts of females. In the first column of the table the name of the line or designation of the cross is indicated, in the second—the total number of flies, in the third—per cent of expression of eyeless, in the fourth—theoretical computation of the percentage of eyeless, provided there is strict intermediate expression; the fifth column shows the difference error; the 6th—significance of difference between the values actually obtained and those theoretically computed. And finally, in the last column is given the coefficient of dominance calculated after Zeleny's formula ([18]): $C = \frac{AA - AA_1}{AA - A_1A_1}$. In this formula AA and A_1A_1 denote homozygotes and AA_1—hybrids.

In our experiments we have been dealing with 6 types of females: 1. All chromosomes+lines (I*A* and U_2). 2. All chromosomes —lines (No 6).

3. All chromosomes neutral (*C* and *B*). 4. Half of the chromosomes are +, half of them are neutral. 5. Half of the chromosomes are —, half of them are neutral. 6. Half of the chromosomes are +, half of them are—. We shall be concerned with types 4, 5 and 6.

In types 4 and 5 selected lines were crossed with unselected ones. The result of all crosses has been the same: the expression of the selected line was dominant. In none of the cases Zeleny's [18] coefficient of dominance is less than 0.5. The difference between obtained and theoretically computed values for crosses with + lines is positive and for crosses with—lines negative, which again testifies to the dominance of characters peculiar to selected lines. In 3 cases the said difference is absolutely significant, in one case it approaches significance, in two cases (crossing with the Berlin line), though statistically insignificant, it has the same sign.

The crossing of the + line with the —line gives some kind of dominance, not quite significant, of characters peculiar to the —line, which is easily understood if account be taken of the conditions of the formation of this line: for over 7 years selection for viability has been operating under conditions of mass culture; viability was followed by a drop in the expression of eyeless. Lines U_2 and *N*1*A* have been subjected to selection but within a period of a few months.

From the experiments it can be seen that selection for some or other degree of expression of a character is followed by increased dominance of this degree of expression as compared with the condition in absence of selection.

It means that the evolution of dominance may proceed as a result of direct selection for such or other characters. In nature dominance will arise as an accessory result of adaptive evolution. Evolution of dominance does not proceed in a manner different from the one of general evolution, but is an essential consequence of the latter.

Treating the evolution of dominance as a result of direct selection for characters enables one to realize the rôle conditions of development play in the origin of dominance and its expression (works of Michurin and Lyssenko); at the same time such a conception is a synthesis of positive features from various theories of dominance (Goldschmidt, Fisher, Wright, Haldane, Muller).

The inference as to the rôle of direct selection in the evolution of dominance is in perfect agreement with works of Harland ([9], [10]) on crossing various species and races of cotton plants and is nearly identical with his conclusion on the direct adaptive character of modifiers of dominance.

Conclusions: Dominance follows as a result of direct selection for maximum or minimum expression of some or other character.

In nature it is an accessory product of adaptive evolution. The way of evolution of dominance is identical with that of the evolution of organisms.

Laboratory of Phenogenesis.
Institute of Evolutionary Morphology.
Academy of Sciences of the USSR.

Received
15. I. 1939.

REFERENCES

[1] С. Давыдов, Селекция с.-х. животных (1936). [2] R. Fisher, Amer. Nat., **62** (1928). [3] R. Fisher, Genetical Theory of Natural Selection, Oxford (1930). [4] R. Fisher, Philos. Trans., B, **225** (1935). [5] R. Fisher, Proc. of the Royal Soc., B, **125** (1938). [6] R. Goldschmidt, Physiol. Genetics (1938). [7] Goodal, Amer. Nat., **71** (1937). [8] J. Haldane, Amer. Nat., **64** (1930). [9] S. Harland, C. R. Acad. Sci. URSS (1933). [10] S. Harland, Biol. Rev., **11** (1936). [11] М. Камшилов, Биол. ж., IV (1935). [12] Т. Лысенко, Теорет. основы яровизации (1936). [13] И. Мичурин, Итоги 60-летних работ (1936). [14] W. Stanley, J. of Exp. Zool., **69** (1935). [15] Н. Тимофеев-Рессовский, Ж. экспер. биол. (1925). [16] S. Wright, Amer. Nat., **63** (1929). [17] S. Wright, Amer. Nat., **68** (1934). [18] Zeleny, J. of Exp. Zool., **30** (1920). [19] H. Muller, Proc. VI Congr. Genet., I (1932).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

PLANT PHYSIOLOGY

NEW DATA ON THE COURSE OF DEVELOPMENT OF THE EAR OF WHEAT

By A. A. SAPEHIN, Member of the Academy of the Ukrainian SSR

During the first investigation of the development of the ear of wheat (1) my attention was attracted by the fact that the beginning of the formation of the sporogenous tissue approximately coincides with the period when long day is no more necessary for the further development of the wheat plant. I thus felt free to assume that the beginning of sporogenesis coincides with the beginning of the third stage of development of the wheat plant. The experimental verification of this statement was made by me in the summer of 1938. The procedure was as follows.

Five varieties were included in the experiment, viz., Aurora, Prelude, Novinka, Caesium and *T.* v. *ferrugineum*. Among them the variety Aurora was developing at the light stage under the experimental conditions with greatest speed, Prelude was the next, then followed Novinka, Caesium, while *T.* v. *ferrugineum* was the slowest.

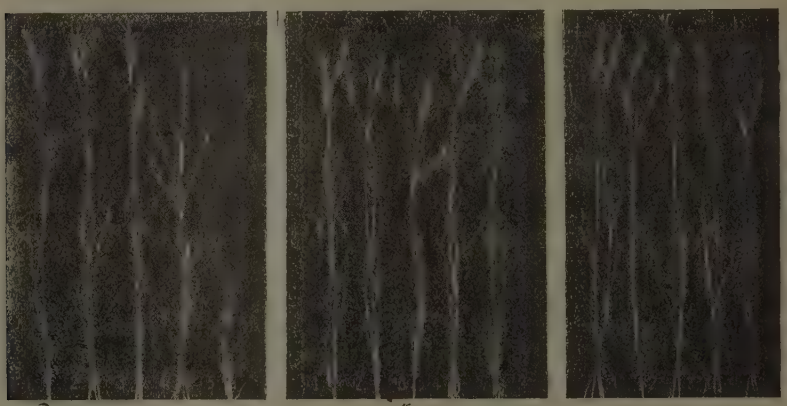
Seeds were planted in pots on April 29. Short day (10 hours duration) was given till May 21. Beginning with the 21st of May, the experiment was continued under the conditions of long day, and the first fixation of the stem-tips was made in order to check their condition. After 15 days from the beginning of the light stage one third of the plants of each variety were placed again under conditions of short day (10 hours), and at the same time a control fixation of the stem-tips was made. After twenty days from the beginning of the light stage another third of plants of each variety were transferred to the short day, and the control fixation was made. The last third were transferred to short day after 2 days from the beginning of the light stage, and the control material was fixed at the same time. All the plants were harvested simultaneously on the 45th day from the beginning of the light stage. The condition of development of each variety at the time of harvest is shown on the photograph.

The investigation of the fixed material gave the following results. On the day when the first third of the plants were transferred back to short day, in the variety Aurora anthers were already differentiated in the outer flowers and the sporogenous tissue became discernible; in the variety Prelude large stamen-protuberances were present, in the variety Novinka the stamen-protuberances were clearly differentiated, while in the variety Caesium the stamen-protuberances were indicated, and in the variety *ferrugineum* the spikelet-protuberances were just started. As may be seen from the photograph, at the time of harvest the variety *ferrugineum* had no ears, while

the latter were normally developed and had normal structure in all the other varieties.

Thus, toward the moment when wheat no longer requires long day for normal development, the formation of stamen-protuberances goes on as well as preparatory cell divisions which give rise to the spore-producing tissue.

On the day when the second group of plants was returned to short day, variety Aurora possessed already in the outer flowers spore-producing tissue composed of large cells and started developing inner flowers in the spikelets; variety Prelude was somewhat behind, in the variety Novinka spore-producing tissue was clearly visible and inner flowers were developing, the same being true of the variety Caesium; while in the variety *ferrugineum* there were just indicated the stamen-protuberances in the outer flowers. Toward the day of harvest it already possessed a rather well developed ear which, however, had not yet escaped from the leaf-sheath.



1, Aurora; *2*, Prelude; *3*, Novinka; *4*, Caesium; *5*, *ferrugineum*.
For explanation see text.

The second experimental group thus confirmed the above conclusion drawn from the data secured from the first group of plants.

In the third group of plants on the day when it was returned to short day, the formation of the spore-producing tissue of the outer flowers was found to near its completion in the varieties Aurora, Prelude, Novinka and Caesium, while in the variety *ferrugineum* the spore-producing tissue was just half ready. Toward the day of harvest all the experimental varieties formed ears.

The third experimental group thus similarly shows that at the beginning of the third stage when wheat no longer requires long day for the normal development, first cell divisions in the stamen-protuberances of the outer flowers are released which bring the spore-producing tissue into existence.

In my preceding work [1] I have discovered a special phase of development of the ear during which processes of some sort take place which are preparatory to the following stretching and thickening of the stem-tip and to formation of spikelet-protuberances on it. This preparatory phase lasts for a few days and begins with the light stage: under the conditions of Moscow in 1937 and 1938 it lasted 4—5 days in Aurora and Prelude, about 9 days in *Lutescens* 062, about 12 days in *ferrugineum*, etc. The general aspect of the

development of the ear and a small preliminary experiment of the year 1937 enabled me to expect that the preparatory phase is the phase for determination of the number of spikelets per ear. In 1938 I have conducted a series of experiments in order to check this supposition. As material for the experiment was taken the variety *Lutescens* 062; the external agents tried were X-rays, excess and shortage of water, low temperature and a number of other influences which will not be considered here.

The experiment was conducted as follows. The experimental plants were placed from the beginning (seed planting) under conditions of short day (10 hours) and remained thus during 3 weeks; they were then all transferred to long day. Each experimental group consisted of 4 pots containing 5 plants each; the control for all the experiments consisted of 12 pots. The plants of the first experimental series were irradiated once with a dosage of 1000 *r*; one group—on the 1st day of the light stage, the other—on the 2nd day, the third—on the 3rd day and the fourth—on the 5th day. The plants of the second series were irradiated 4 times with dosages of 250 *r* each; one group on the 1st, 2nd and 5th day of the light stage, the other—on the 6th, 7th, 8th and 9th day. In the third experimental series two groups of plants received plenty of water (the pots stood in water), one of them during the first four days of the light stage, the other—during the 7th, 8th, 9th and 10th days; the third group remained during the first four days of the light stage not watered at all. Finally, in the fourth experimental series one group of plants was developing during the first four days at a temperature which was 4—6° below that at which all the other experimental groups were kept.

The result of the experiment is presented in the table.

Alteration of the Number of Spikelets per Ear by Means of External Influences during Determinative Phase of Development

Agent	Number of spikelets
Control	16.4
1000 *r* on the 1st day	13.2
1000 » » » 2nd »	13.6
1000 » » » 3rd »	13.6
1000 » » » 5th »	12.5
250 *r* on the 1, 2, 3 and 5th day each	14.5
250 » » » 6, 7, 8 » 9th » »	13.7
Excess of water on the 1— 4th days	16.9
» » » » » 7—10th »	17.0
Shortage of water on the 1—4th days	14.4
Lowered *t*° on the 1—4th day	15.2

The preparatory phase of development of the ear actually appears to be the determinative phase. Whatever favourable the conditions of life prior to or following the phase in question might be, even a short unfavourable influence upon the plant during this phase is sufficient to effect formation of a reduced number of spikelets when the stem-tip is transformed into the ear. Vice versa, improvement of the life conditions during the preparatory period leads to an increase of the number of spikelets per ear.

I expect to begin verification of the practical conclusions from the above data in 1939, in co-operation with a number of agricultural experiment stations.

The above influences during the first days of the light stage which have changed the number of spikelets per ear did not influence the number of flowers per spikelet: their determination should be sought for at the end of the second or at the beginning of the third stage.

N. Z. Stankov (2) in his interesting work on the structure of the yield has made an attempt to decipher the correlation between the developmental stages and the so-called elements of the structure of yield; in citing my work he fell in a number of errors which misrepresent my attitude and should be corrected here. The interrelations noted above, it seems to me, are expressed in the following manner under conditions which are n o r m a l for the wheat plant. During the stage of yarovization the wheat develops leaves and tiller. The formation of leaves and the tillering is not limited, as erroneously stated by Stankov, to the stage of yarovization, but may continue beyond its completion. Moreover, upon appearance of conditions which are necessary for passing the light stage, namely during the phase preparatory to the ear formation, the stem-tip continues to form leave-protuberances without noticeable alterations in its morphology. In each individual stem of a wheat plant the formation of leaves proceeds both against the background of yarovization and during the first days of the light stage. Then follows a rapid lengthening and thickening of the stem-tip, where the spikelet-protuberances are formed. Toward the end of the light stage, i. e. the moment when the wheat plant no longer requires long day for the normal development, the spikelet-protuberances have time enough for formation of rudiments of the glumae and paleae of the outer flowers;the beginning of the next, third stage coincides with the formation of the stamen-protuberances in the outer flowers. About the same period the number of the inner flowers is determined. The development of the outer flowers of the spikelet thus proceeds against the background of the light stage, while that of the inner one—against the background of the third stage. As regards fertility of the flowers, one may judge from the general aspect of their development that it is decided later still.

Direct experiments for finding the period of determination of the inner flowers of the spikelet are being planned by me for the summer 1939. At the same time will be studied the possibility of changing the number of spikelets by external influences during the period of their setting; such a possibility is not excluded theoretically.

Received
3. I. 1939.

REFERENCES

[1] A. A. S a p e h i n, C. R. Acad. Sci. URSS, XVIII, № 3 (1938). [2] С т а н к о в, Хим. соц. земледелия, № 5 (1938); Селекция и семеноводство, № 11 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

PLANT PHYSIOLOGY

ON THE DYNAMICS OF GROWTH-SUBSTANCES OF THE GROUP B IN PLANTS

By K. I. GAVRILOV

(Communicated by A. A. Richter, Member of the Academy, 13. XII. 1938)

Growth-substances of the group B or bios are known strongly to affect the development of lower microorganisms in which they are present. This was safely established since Wildiers' [9] times in regard to yeasts, putrefactive bacteria [6], parasitic fungi [7], etc.

At first it was assumed that these substances are of importance for lower organisms only, but later they were found to occur in great numbers in higher plants too. Investigations carried out in that field by Suchorukov, Kling and Kliacko [5] have shown that B substances abound in algae, in the barley embryo, in leaves of lilac etc., that their formation proceeds in green cells, especially under the action of the highly refrangible part of the solar spectrum.

On studying the seed embryos of *Zea Mays* and *Triticum vulgare*, as well as buds and leaves of *Betula verrucosa*, Dagys [2-4] found sufficient amounts of growth-substance, which contributed greatly toward the division of yeasts and the increase of dry weight of *Aspergillus niger*.

Sufficient accumulation of literature is now available on the occurrence of B substances in some or other plant organs and particularly in vigorously growing embryonic tissues [8]. In the present paper we make an attempt at solving the question as to the rôle of the B substances in the development of higher plants and their dynamics in connexion with seasonal changes in nature. We have centered our attention on the leaves, since the synthesis of those substances seems to take place in them.

M e t h o d. In determining growth-substances B we have used a modification of the «yeast» method developed by Verner and Kling [1]. The relative quantity of B substances was determined by the increment of yeast cells, which have multiplied over night in the test flasks as compared to the control. The increment was calculated by counting the yeast cells with a Thoma-Zeiss counting camera. The yeast was cultivated on Hayduk's medium, wherein asparagine had been replaced by a proportional quantity of NH_4NO_3. The extract was prepared in the following manner: 0.5 g of the vegetable mass was ground in a porcelain mortar. Thereupon the ground mass was transferred to an Erlenmeyer's flask with 50 cm^3 capacity, containing 25 cm^3 of distilled water, where it was boiled for 3 minutes from the moment boiling had begun.

The nutrient medium was poured into Erlenmeyer's flasks, 25 cm^3 capacity each. Then 1.5 cm^3 of filtered extract was introduced into one series of the flasks; it was repeated thrice, the second series serving as control.

After 20 minutes of sterilization in a Koch's apparatus the flasks with the nutrient medium were inoculated with 1 cm^3 of homogeneous yeast suspension, and we took care to maintain this homogeneity throughout all the tests. We have used one loop of the same strain of yeast *Sacchar. cerevisiae* stirred in 12 cm^3 of distilled water. The external diameter of the loop was 2 mm. Yeast in pure culture had been kept up for several months on Hayduk's agar medium (4 g of agar-agar per 100 cm^3 of medium). During the said period several transplantations were made to new portions of solid medium and that secured their bios starvation.

Investigations were carried on partly in 1937 and chiefly during the spring, summer and autumn of 1938. As experimental plants served: *Tilia cordata*, *Betula pubescens*, *Fraxinus excelsior*, *Syringa vulgaris* and *Ulmus effusa*.

Investigations carried out after the method described have shown that the amount of the B substance materially varies with the age of buds and leaves. Resting buds have a relatively high content of B substances, accelerating the division of yeast cells. They are particularly abundant in the buds of birch and lime-tree.

The extract from these buds increases the rate of development of yeast 10—11 times against that of the control. The content of B substances (Table 1) is greatly reduced in buds, when they are swelling during the incipience of growth. This reduction, in our opinion, is due to the loss in B substances during cell division, when processes of internal differentiation are taking place in the bud.

Table 1

Plants	Object of investigation	10.IV		Object of investigation	20.IV	
		Number of yeast cells	Increment in % of control		Number of yeast cells	Increment in % of control
Tilia cordata	Resting buds	245.4	1115.5	Buds beginning to grow	46.5	186.0
Betula pubescens		257.0	1168.2		75.0	300.0
Fraxinus excelsior		73.5	334.1		47.5	190.0
Syringa vulgaris		68.4	310.9		50.0	200.0
Ulmus effusa		32.2	146.4		—	—
	Control	22.0	100.0	Control	25.0	100.0

Then, gradually, with the appearance of young green leaves, the quantity of B substances increases again, and goes up until the leaf attains its full development (Table 2).

The synthesis and dynamics of B substances are strongly influenced by external factors, by temperature and sun radiation in particular.

On May 25, while taking one of the regular samples, we obtained data which showed markedly lower figures. At that time it grew considerably colder in the Perm district. There was a drop of temperature to zero. It was snowing. Under the action of negative factors the metabolism went down appreciably and the production of B substances stopped.

The weather continued cold till May 26. Then, as it was growing warmer, the amount of B substances was rapidly increasing, and on the 31st of May it was found to be well above the former level (Table 2 and figure).

Table 2

Plants	Object of investigation	4.V		Object of investigation	15.V		25.V		28.V		31.V	
		Number of yeast cells	Increment in % of control		Number of yeast cells	Increment in % of control	Number of yeast cells	Increment in % of control	Number of yeast cells	Increment in % of control	Number of yeast cells	Increment in % of control
Tilia cordata	Embryonic leaflets	75.6	360.0	Leaves	270.2	540.4	53.5	250.0	145.8	510.0	112.0	746.6
Betula pubescens		96.9	461.4		181.0	362.0	32.1	150.0	85.8	300.0	78.0	520.0
Fraxinus excelsior . . .		—	—		232.0	464.0	40.6	190.0	104.3	364.7	63.2	421.3
Syringa vulgaris		56.8	270.5		151.7	303.4	24.1	112.2	122.1	427.0	95.0	633.3
Ulmus effusa		58.7	280.0		290.0	580.0	20.2	94.4	52.5	184.0	57.1	380.6
	Control	21.0	100.0	Control	50.0	100.0	21.4	100.0	28.6	100.0	15.0	100.0

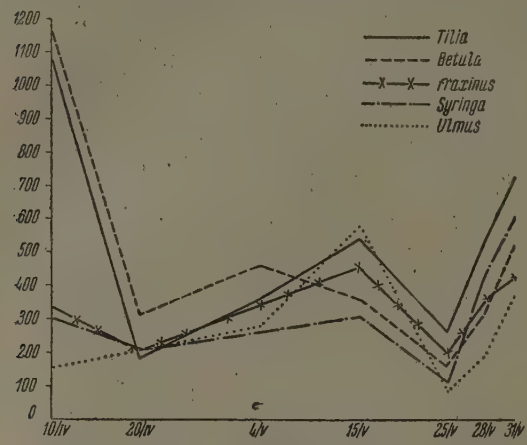
Table 3

Plants	Object of investigation	11.IX		21.IX		Object of investigation	11.X		Object of investigation	21.X	
		Number of yeast cells	Increment in % of control	Number of yeast cells	Increment in % of control		Number of yeast cells	Increment in % of control		Number of yeast cells	Increment in % of control
Tilia cordata	Leaves	—	—	—	—	Fallen leaves	190.5	952.5	Leaves losing chlorophyll	118.7	756.0
Betula pubescens		58.0	386.6	24.0	240.0		81.2	406.0		—	—
Fraxinus excelsior		63.0	420.0	20.0	200.0		48.0	240.0		32.2	205.1
Syringa vulgaris		67.0	446.6	34.0	340.0		52.0	260.0		56.0	356.6
Ulmus effusa		—	—	—	—		60.0	300.0		25.2	160.5
	Control	15.0	100.0	10.0	100.0	Control	20.0	100.0	Control	15.7	100.0

No tests were made in July and August. They were resumed in September and October. During the first half of September the quantity of B substances remained at a high level, but later on, with the approach of autumn, a small decrease was observed with a subsequent increase when leaves were intensely falling (Table 3).

Leaves of lilac presented an identical picture, though somewhat later, owing to the retarded fall of their leaves.

Dagys ([3]) explains the accumulation in falling leaves of growth-substances, accelerating the division of yeast cells, by the cessation of their reflux to the stem. Falling leaves are high in those substances. Evidently we are dealing here with a phenomenon which had been once observed by Suchorukov, Kling and Kliacko ([5]) — the liberation of B substances (bios) upon breakdown of protein.



Dynamics of B substances in buds and leaves during April and May.

Having revealed the effect of external factors upon the dynamics of B substances in leaves of plants, we have made an attempt to find out whether daily variations take place in the amount of those substances. The regular change of the complex of factors in the course of 24 hours does not fail to exert its influence upon the plant's vital activity. And it was found that B substances are liable to appreciable changes too (Table 4).

The table shows that the amount of B substances increases toward the evening and the highest content is reached toward 4—5 o'clock in the morning. Then a decline begins, and in the afternoon, about 2—3 p. m.,

Table 4

Object of investigation	5 a. m.		2 p. m.		9 p. m.	
	Number of yeast cells	Increment in % of control	Number of yeast cells	Increment in % of control	Number of yeast cells	Increment in % of control
Leaves of *Syringa vulgaris*	144.0	960.0	50.0	333.3	95.0	633.3
Leaves of *Tilia cordata* . .	261.0	1740.0	37.0	246.6	112.0	746.6
Control	15.0	100.0	15.0	100.0	15.0	100.0

it drops to minimum. Throughout the test there was quite steady warm sunny weather. The temperature on May 31, 1938 (the date of the test), was at 5 a. m. 10°C, at 2 p. m. 25°C and at 9 p. m. 15°C. A similar picture was observed in other samples, taken on days with nearly identical meteorological factors, however, it did not come to show on cloudy rainy days. Though unable as yet to interpret these data properly, we can safely say that the migration of B substances in the plant is closely related not only to the energy of form-building

processes, but to the accumulation of organic matter as well. Evidently the «night rest» of plants furthers the accumulation of B substances in leaves.

Alongside of the study of leaves and leaf buds, we investigated in some plants their floral buds as well. It appeared that floral buds, as compared to leaf buds, are considerably higher in B substances accelerating the development of yeast (Table 5).

Table 5

Object of investigation	10.IV		4.V		Note
	Number of yeast cells	Increment in % of control	Number of yeast cells	Increment in % of control	
Floral buds of *Ulmus*	114.7	521.4	127.9	609.0	The two kinds of buds were taken simultaneously from one shoot
Leaf buds of *Ulmus*	33.0	150.0	58.7	280.0	
Floral buds of *Fraxinus*	85.7	390.0	65.0	309.0	
Leaf buds of *Fraxinus*	72.8	330.9	46.2	220.0	
Control	22.0	100.0	21.0	100.0	

The higher content of B substances in flower buds suggests the idea that the latter influence division of the cells building up floral organs, and this results in the flowers pushing during the period of efflorescence.

Conclusions. 1. Growth subtances of the group B are present in great quantities in buds and leaves of *Tilia cordata*, *Betula pubescens*, *Fraxinus excelsior*, *Syringa vulgaris* and *Ulmus effusa*.

2. These substances are synthesized chiefly in leaves, but the possibility of synthesis taking place in each vegetable cell separately does not seem to be excluded.

3. Under the influence of external conditions of temperature and sun radiation, the outcome of these substances is subject to strong fluctuations, but irrespective of that their dynamics are governed by definite regularities, namely: decrease during the swelling of buds, increase with the formation of young leaflets, a relatively constant level in completely shaped leaves, insignificant decline a few weeks prior to the autumnal fall of leaves, with a subsequent increase during the fall of leaves.

4. Within the 24-hour period in warm sunny weather the quantity of B substances increases toward the evening, reaching its maximum content toward 4—5 o'clock in the morning, with a subsequent decrease about 2—3 o'clock in the afternoon.

5. The higher content of B substances in floral buds suggests the idea that the latter affect the division of cells building up floral organs.

Laboratory of General Biology.
Perm State Medical Institute.

Received
22. XII. 1938.

REFERENCES

[1] А. Вернер и Е. Клинг, Труды комиссии по ирригации Академии Наук СССР, вып. 3 (1934). [2] J. Dagys, Protoplasma, **24**, 14 (1935). [3] J. Dagys, ibid., **26**, 20 (1936). [4] J. Dagys, ibid., **28**, 205 (1937). [5] K. Suchorukov, E. Kling a. D. Kliacko, C. R. Acad. Sci. URSS, I, № 7 a. 8 (1935). [6] K. Suchorukov a. Eppel-Bogoslovskaya, C. R. Acad. Sci. URSS, I, № 9 (1935). [7] К. Сухоруков, Гербер, Баранова и Бородулина, Уч. зап. Сарат. гос. ун-та, **10**, вып. 1 (1933). [8] K. V. Thimann a. J. Bonner, Physiol. Review, **18**, № 4 (1938). [9] E. Wildiers, La Cellule, **18**, 31 (1901).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

DEVELOPMENT MECHANICS

SOME DATA ON THE DETERMINATION OF THE EAR IN *TRITON TAENIATUS*

By A. S. GINSBURG

(Communicated by I. I. Schmalhausen, Member of the Academy, 29. XII. 1938)

When studying the phenomenon of induction of organs in the embryonic development of amphibians, we subjected the ectoderm from the region of the presumptive ear to the action of a foreign inductor—the optic cup.

Our experiments consisted in transplanting a section of ectoderm from a region, where the material of the future ear vesicle is located, into the eye region. As donors served the embryos of *Triton taeniatus* at various stages of development, beginning with the stage of an early neurula when the dorsal furrow has just appeared, and the neural folds are not yet raised, and ending by the neural tube stage (Harrison's stages 13 to 21). As hosts were taken embryos of the same species, chiefly at the stage of neural tube, and of an early tailbud.

From the donor, previously stained in Nile blue sulphate, was cut out a square piece of ectoderm of the ear region, which includes the material of the auditory plakode (figure). The grafts considerably exceeded in size the future plakode, since it was necessary to take into account the possibility of individual variations of the presumptive rudiment in size and position. At all the stages studied except the last the ectoderm in this region morphologically differs in nothing from the surroundings. Only at the 21st stage, shortly after the closure of the neural folds, the deep layer of ectoderm shows some thickening which, afterwards, turns into a definite auditory plate, then invaginates and forms a primary ear vesicle.

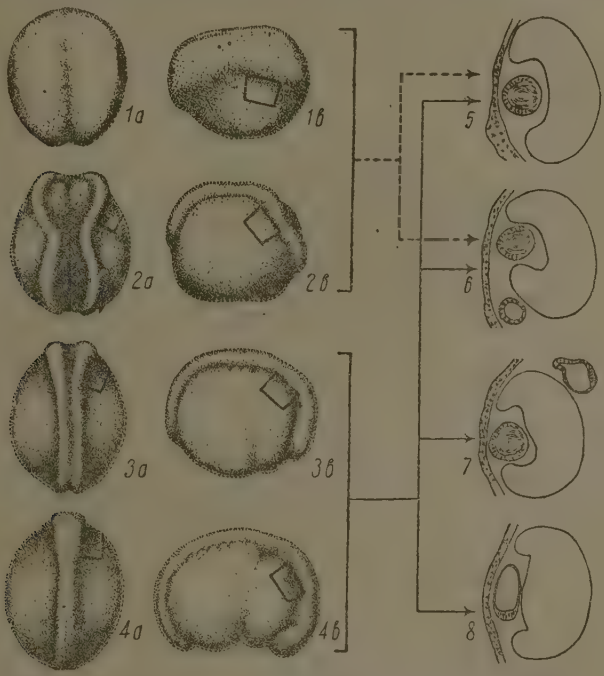
From the right side of the host was removed a lens-forming region of the epithelium together with the outer layer, and on to the optic vesicle laid bare was then placed the piece of the ear ectoderm of the donor. At the time of fixation, the graft not only covered the eye of the embryo, but also the adjoining parts of the head. The hosts were grown until the stage of a cylindrical rudiment of the fore limb, or until the appearance on the limb of two rudimentary digits. 63 such larvae were studied.

Let us now examine separately what happens to that region of the graft which comes in contact with the retinal leaflet of the optic cup after operation, on one hand, and what becomes of its other parts, on the other.

The latter, situated outside of the eye pupil, frequently forms vesicles and defective labyrinths.

The ectoderm from an early and middle neurula (Harrison' s stages 13 to 17) forms only small vesicles from 50 to 120 μ in diameter, as a rule, one in each case, rarely two. The vesicles have a regular spheric or oval

shape, and show no signs of division into sections. Their wall is formed of cylindrical, cubic or flat epithelium, and has no thickenings—sensory areas—characteristic of the ear. Variation in wall structure is connected with the stage of host fixation; in embryos fixed at comparatively late stages the vesicles have a thinner epithelium. Some embryos were fixed 2 days after operation. In three of them were found vesicles, all of which had a very small cavity and a thick wall with cell nuclei located, sometimes at different levels; they were very much like young normal ear vesicles. 6—7 days later (stage of two-digit-limb) the wall of the vesicles has, already, the character of flat epithelium, similar to the epithelium of the indifferent part of the wall of a normal labyrinth at the same stage.



Scheme illustrating the origin of the graft and its development. 1—4 stages of donors (*a*, dorsal view; *b*, lateral view); *1*, early neurula; *2*, middle neurula; *3*, late neurula; *4*, embryo at the neural tube stage. The piece of ectoderm taken for transplantation is outlined. *5—8*, formations having developed from the transplanted ectoderm in the pupil and outside of the eye (on cross-sections of the head of the host).

The ectoderm taken from a late neurula and from an embryo on the neural tube stage, alongside of such vesicles also forms other, usually somewhat larger ones, in which we find thickened wall areas of a typical structure, and a small digitate or inflated appendix, undoubtedly representing the ductus endolymphaticus. These structures—sensory areas and endolymphatic appendage—are found both separately, and together, in the same vesicle. Vesicles of such a kind must be considered as true though defective labyrinths.

The variation of the properties of the ectoderm of the ear region during neurulation tells not only upon the structure of the vesicles which develop from it, but the total per cent of cases of their origination also increases. This may be seen from the following table which summarizes the results of the experiments.

Stage of donor (according to Harrison)	Number of cases studied	Presence of epithelial vesicles	
		Total	With structures characteristic of the ear (sensory areas, ductus endolymphaticus)
13	4	1	—
14	4	—	—
15	9	1	—
16	15	2	—
17	5	2	—
18	7	1	1
20	11	7	3
21	8	6	3
Total	63	20	7

Thus, already at the stage of early and middle neurula, the ectoderm from the region of the presumptive ear in the newt is not indifferent—being grafted into the eye region it shows, at least in some cases, a tendency to invagination and formation of a vesicle (which corresponds to the first phase of the normal development of an ear). The process does not advance further than the formation of a vesicle; the wall of the vesicle gradually becomes thinner, but shows no differentiation. At the stages of a late neurula and of closure of neural folds, the same ear ectoderm appears to be determined (may be not yet in all individuals) for the formation of a labyrinth; this is displayed in the foreign environment by the formation in most cases of vesicles with structures characteristic of this organ*. No development from the grafted ectoderm of labyrinths approaching normal ones as to their structure—with semi-circular canals, subdivision into sacculus and utriculus, etc.,—was observed. This means that either the surrounding conditions in the given experiments are unfavourable to normal differentiation of the membranous labyrinth, or else that towards the end of neurulation, the process of determination of this organ is not yet completed.

Now let us dwell on the development of that part of the transplantate which after operation was in contact with a foreign inductor—the optic cup. The ectoderm of an early and middle neurula always forms here a lens, usually one, more rarely two and even three. If there is a single lens, then it is smaller than that of the left (not operated) eye, and it is frequently less differentiated. The difference is, sometimes, so considerable that it cannot be fully accounted for by the younger age of the donor; thus, it seems to be partly due to a certain local specifity of the transplanted ectoderm, whose properties hamper the formation from it of any organ except the ear. The peculiar tendencies of development inherent to this ectoderm are, however, still not strong enough to resist the inducing action of the optic cup.

The ectoderm taken from embryos at later stages of development does not always behave in the same way. In 3 cases, in the cavity of the optic cup instead of a lens were found defective labyrinths, differing in nothing whatever from those which are formed outside the eye. Though the vesicles closely adhere to the retina, the eye has no specific influence on their differentiation. Two of those ears were formed by the ectoderm taken from a late

* The process of determination of the ear in the newt is likewise characterized by a series of xenoplastic transplantations of the ear ectoderm of the same *Triton taeniatus* into the ear region of embryos of *Bombinator igneus*.

neurula, one—from an embryo at the neural tube stage. This points to the fact that at the stage of a late neurula, prior to the morphological individualization of the auditory plakode, the ectoderm in the ear region may possess definite tendencies of development, strong enough to develop according to its origin not only when in a neutral environment, but also when put in contact with an active foreign inductor.

Conclusions

1. Ectoderm from the ear region, taken from an embryo of *Triton taeniatus* at the stage of an early or middle neurula, and transplanted into the region of the eye of an older embryo of the same species, can form more or less independently only undifferentiated epithelial vesicles. This material reacts to the contact with the optic cup by the formation of a lens.

2. At the stages of late neurula and of closure of neural folds the same section of ectoderm proves to be more specific; when grafted into the region of the eye, it forms vesicles which have a structure characteristic of the ear-sensory areas and the endolymphatic duct. At this stage, the tendencies to form a labyrinth in the ectoderm of the ear region, at least in some individuals, are already so strong that a graft taken herefrom continues to develop in the determined direction even when put in contact with a foreign inductor.

Sewertzov Institute of Evolutionary Morphology.
Academy of Sciences of the USSR.
Moscow.

Received
15. I. 1939.

REFERENCES

[1] Karl Röhlich, Roux' Arch, **118**, 164—199 (1929). [2] M. H. Choi, Fol. anat. jap., **9**, 315—332 (1931). [3] Anna Domacavalli, Rivista di biol., **22**, 245—248 (1937). [4] O. Sidorov, Arch. anat. hist. and embr., **16**, 25—71 (1937) (Russian). [5] H. Spemann, Arch. f. Entw. Mech. d. Org., **15**, H. 3 (1902). [6] Oskar Levy, ibid., **20** (1906).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

ANIMAL PHYSIOLOGY

DEVELOPMENT AND BEHAVIOUR OF THYROIDECTOMIZED YOUNG ROOKS (*CORVUS FRUGILEGUS* L.)

By G. A. WASSILIEV and A. A. WOITKEWITSCH

(Communicated by L. A. Orbeli, Member of the Academy, 25. XII. 1938)

Investigations of recent years have shown that the complex unconditioned reflex or instinct is underlain not only by a nervous, but also by a humoral basis. Ignoring of humoral regulation when analyzing animal behaviour may be considered as a method acceptable for the study, say, of the food reflex in mammals, but it may lead to erroneous conclusions when other kinds of activity are investigated, for instance, the maternal instinct in mammals, or the behaviour of representatives of other classes of vertebrates.

According to L. A. Orbeli ([6]), in birds the instinctive activity and that due to conditioned reflexes are expressed in a nearly equal degree. Therefore birds offer an object of utmost interest for the study of neuro-humoral regulation of behaviour. It is obvious that most suited for this kind of investigation is the period of rapid succession of instinctive reactions, which take place, for example, in the course of reproduction or during post-natal development.

Excellent material for such investigations is afforded by representatives of the nestling group (nidicolae). The period of their development as compared with that of precoces (nidifugae) is very short; in the course of their post-embryonic development these nestlings pass through a number of distinct forms of nutritional behaviour: 1) passive accepting of food; 2) active «begging» for food in the nest; 3) active «begging» when following the parents and, finally, 4) feeding themselves.

These changes seem to be caused by the development of new nervous mechanisms, taking place alongside of a successive transition from old nervous way to new ones, which is effected by means of humoral, particularly endocrine factors.

The development of birds is proceeding under the control of the endocrine system. Among the components of the latter the thyroid gland plays an important part in the developmental processes. The character of the development of the thyroid apparatus differs in birds of the two above groups ([1,4]). Thus, in altrices the biological activity of the thyroid gland at the very moment of hatching is practically zero, while during the subsequent period it soon completes differentiation and enters a stage of increased activity. Taking into account such distinct variations of the hormonal formula of the organism, we naturally had to investigate what rela-

tion there exists between the endocrine system, the thyroid gland in particular, and the changes observed in the behaviour of the nestlings in the course of their development. As a means that would possibly lead us to the solution of the problem, we considered the experiments on nestlings which had the thyroid gland removed. Besides, our experiments could contribute to the knowledge of the form-building rôle of the glands of internal secretion, inasmuch as the effect of thyroidectomy on the development of altrices remained totally unstudied.

The experiments were carried out in the Ornithological Laboratory of I. P. Pavlov Biological Station in Pavlovo (Koltushi); for the last few years a method of raising young rooks was worked out at this laboratory, which secured their normal development, provided the young are taken from the nest not before they are 5—7 days of age.

Therefore in our experiments we have used nestling rooks not less than 7 days old. Birds which were taken from the nest used to be kept for one or a few days* in the laboratory before they got operated. Each nestling was individually fed 7—8 times a day. The birds were fed till satiated, i. e. till they refused to open their beaks upon repeated utterance of the low sound «car», otherwise an unconditioned stimulus of the food reflex in a nestling at an early age ([2],[3]). Composition and consistence of the food were chosen in accordance with the data obtained upon opening of stomachs of young and adult rooks at the period of feeding, vitamin and mineral components being added.

We will not dwell on the technique of thyroidectomy and the post-operative treatment, of which detailed description had been given before ([5]); we shall merely note that both lobes of the gland were removed simultaneously. After the operation, if there was no appreciable loss of blood, the behaviour of the birds did not differ from that of normal birds and they took food readily. There were altogether 36 young rooks thyroidectomized. As controls served normal young at respective ages or birds which had been subjected to incision in the field of operation, having thus their gland parenchym traumatized. As controls could also be used thyroidectomized birds whose thyroid tissue had regenerated, as well as young rooks castrated or thymectomized for other purposes, in which the general trauma caused by operation by far exceeded that in thyroidectomized specimens.

Passing to the description of the results obtained, it should be noted that thyroidectomized birds proved less viable than controls. Fluctuations of the air temperature often proved fatal to thyroidectomized birds, which had scarcer plumage. Control birds seemed to delight under identical conditions. Thus, 100 days after the operation, out of a total of 36 thyroidectomized birds but two were alive; of 20 control birds 16 survived.

Experimental birds, as compared with normal and control ones, lagged behind in growth after the operation. In Fig. 1 are plotted data on the growth of young rooks, thyroidectomized at the age of 10 days. As may be seen from the corresponding curve, the growth of the young control rook (No 18) proceeds most intensively within the first 20 days. Within the subsequent period (up to the 35th day) there is little change in the weight of the bird, which should, apparently, be referred to differentiation processes. Later on some increase in weight is observed, which seems to occur at the expense of increase of the bulk of functional organs, in connexion with the active behaviour of the bird.

---

* Young rooks prior to and 2—3 days after the operation were housed in special constant temperature chambers at a temperature of 30—35°, while mature ones were kept in a room at 20—25°C.

In the thyroidectomized young (No 14) the rate of growth drops immediately after the operation. The period of growth appears more extended. After cessation of growth the thyroidectomized bird remains of a smaller size than the control. In case the operation performed was not complete and the thyroid gland began to regenerate (as found by autopsy), the growth of the bird is inhibited only during the first post-operative period. Afterwards, in connexion with the regeneration of the thyroid gland, the bird attains its normal size. Thyroidectomy at a more advanced age (20 days) results in an almost complete stoppage of growth (see curves in Fig. 2). Ope-

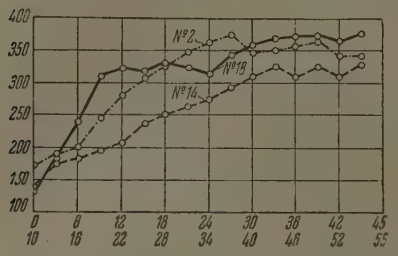


Fig. 1. Size of young rooks thyroidectomized when 10 days old: № 18, control; № 14, total thyroidectomy; № 2, partial thyroidectomy*.

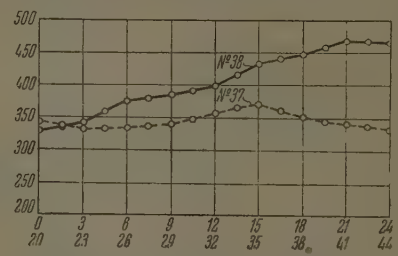


Fig. 2. Size of young rooks: № 38 (control) and № 37 (the latter thyroidectomized when 20 days old)*.

ration at the age of 70 days is followed by no changes either in the size or in the general habitus of the bird.

The inhibition of general growth in experimental rooks, as indicated above, is a specific result of thyroidectomy, since birds of the control groups showed perfectly normal development within equal periods of time. The correctness of the foregoing conclusion is further attested by the results of an experiment carried out under natural conditions. From a nest where usually 3—4 young dwelled, one was taken out, immediately thyroidectomized, and put back to its nest. As control served another young, nearly of the same size, which was left behind in the nest. Thus, during the pre- and post-operative period both young were fed by their parents. The operation was performed on young from 4 nests. The results of one of these experiments are shown in Fig. 3. On the 8th day after the operation the birds were carried away from the nest and housed in the laboratory. During the stay in the nest the operated bird did not gain weight, whereas the control one gained more than 100 g for the same period. The change of conditions, i. e. transportation to the laboratory, produced a great reduction in weight, especially in the control bird. Later on the weight of both was restored, but the difference between the experimental and the control bird remained.

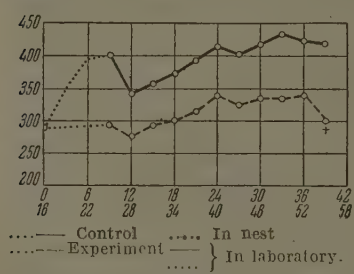


Fig. 3. Experiment with young rooks under natural conditions*.

Parallel to the general growth inhibition, there was observed in the thyroidectomized birds a strong inhibition of the plumage development.

---

* Figures along the axis of co-ordinates express weight in g, those along the axis of abscissae: upper raw—time passed since operation (in days), bottom raw—time passed since hatching (in days).

It is noteworthy that owing to the reasons indicated above, in our experiments we made use of young birds whose plumage has already started to develop. At operation time the basic pteryliae bore papillae at a stage immediately preceding the development of the vanes, or with vanes already developed (sometimes at an advanced stage of development). Consequently, the effect of thyroidectomy could be revealed either during the subsequent stages of development of the feathers, or else in their growth in those pteryliae where they have not yet appeared up to the moment of the operation.

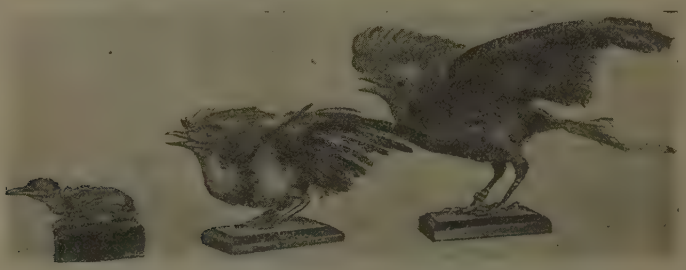
As a matter of fact, in thyroidectomized birds (Fig. 4) the pteryliae of the neck, the under wing-coverts, the feet and partly of the back remained bare. Only those single papillae were developing which had been there before

Fig. 4. Rooks when 40 days old. Above, control; below, operated upon 10 days after hatching.

thyroidectomy took place. Oar-feathers (remiges) and stearing-feathers (rectrices) as well as their coverts, which had attained appreciable development up to the time of operation, continue to grow. However, the rate of their growth is greatly decreased: the growth of quill-feathers in experimental birds is completed 15—25 days later than in control birds. Furthermore, in size, shape and structure these feathers differ greatly from normal ones. They are considerably narrower and shorter. The barbs of the vanes in large feathers are feebly connected with one another, in small feathers they are not united at all, and in the contour part of feathers, instead of an elastic vane, they form something like a «tuft». The proximal part of such feathers either possesses no down at all, or the latter is represented by immature barbs.

Modifications of a general character, on which we shall not dwell in detail, are expressed, as a rule, in disproportional development of separate parts of the body. Particular attention is attracted by a broad skull, somewhat protuberant in the anterior part, bulging «frog eyes», a wide nestling mouth, a large, disproportionally protruding belly, folded skin (Fig. 5).

The behaviour of thyroidectomized birds, as well as their general development differed markedly from the behaviour of control birds, and there is a definite dependence between the effect and the age of the bird at the time of operation. Young birds that are operated on at the age of 10 days showed less alertness, more rapid satiety, slowness of the motion reactions. The food reaction in particular, i. e. a peculiar thrusting of the head and opening of the mouth, was called forth with great difficulty and required iteration of sound stimuli within immediate proximity. The food reaction per se not only showed a lack of normal development in the sense of a more active participation of the wings, feet and the vocal apparatus, but there were even signs of regression to earlier stages—a plain opening of the mouth, accompanied by a single dull cry, instead of a reiteration of ringing notes. Such is exactly the behaviour of the bird during the first days of life, when his thyroid gland is functioning very feebly. Possibly in thyroidectomized birds this phenomenon was but a consequence of loss of appetite and of general drowsiness.



a *b* *c*

Fig. 5. 55 days old rooks: *a*, young rook when 10 days old (initial material at the age when operated upon); *b*, the same rook 45 days after operation; *c*, normal young rook at the same age (55 days).

As the majority of experimental birds perished, it had been possible to watch their behaviour for a relatively short time, from 2 to 3 weeks; it proved, however, sufficient for their controls to change sharply their behaviour and turn into eager, lively, importunately begging for food, fully fledged little rooks. On the other hand, the thyroidectomized bird No 14 remained dull throughout the entire period of observation (45 days). At feeding it extended its wings but did not flap them, as control rooks did. It has not passed from the state of unconditioned reaction to sound and to motion of an object before its eyes to the conditioned reaction at the sight of the experimenter. It had not learned to rise fully to its feet, and to walk, which may be considered as the conservation of a reflex from the early stage, when it was passively waiting for food to be brought to it by its parents.

In case of thyroidectomy performed at a more advanced age (experiments under laboratory and natural conditions) a similar effect was observed. Thus, the young rook No 30 which had undergone operation at the age of 16 days, showed at the beginning but little distinction in behaviour from the control bird. However, subsequently it kept on waiting for the delivery of food to it, often not even turning around to the experimenter, while the control birds were anxiously hopping over to the threshold of the cage or running on the floor after the person who was feeding them. This bird did not learn to differentiate clearly its name, which evidently points to the important rôle of the unconditioned component in its food reaction, characteristic of the passive stage.

Birds which had passed the regeneration of the thyroid gland, went over gradually, though with some delay to the active form of food reaction, responded to the call of their name, clearly differentiating it, but upon completion of growth, in spite of the regular features of an adult bird, possessed a less keen appetite, were subject to inhibition by external stimuli and lacked aggressive reactions, which were rather characteristic of other young rooks. When operation was performed at the age of 70 days, there were no changes observed either in behaviour or in the general development of the birds. Likewise, there were no changes noticeable in the behaviour of young rooks castrated or thymectomized at an early age.

The results of all the experiments performed justify the conclusion that thyroidectomy in young rooks impairs the general growth in the bird, as well as the differentiation of its plumage. The effect produced by inhibition of general growth is greater in young of earlier age. The behaviour of operated young birds is closely dependent upon the degree of the general development of the bird. It is the removal of the thyroid gland that makes that the behaviour of the young birds is fixed to the stage at which they were operated on. Separate stages of the young birds' behaviour that become apparent in the progress of development seem not to be bound up with the hormone of the thyroid gland, since the deviations from norm at each stage are of purely quantitative character. Investigation of the higher nervous activity upon removal of the thyroid apparatus should be performed on adult specimens, in which phenomena connected with growth and development cannot possibly take place.

I. P. Pavlov Institute of Physiology.
I. P. Pavlov Biological Station.
Laboratory of Development Mechanics.
Sewertzow Institute of Evolutionary Morphology.
Academy of Sciences of the USSR.
Leningrad—Moscow.

Received
27. XII. 1938.

REFERENCES

[1] M. Benazzi, Arch. ital. anat. di embriol., **30** (1932). [2] Ю. А. Васильев, Мат. 2-го совещ. по физиолог. проблемам (1937). [3] Ю. А. Васильев, Мат. 3-го совещ. по физиолог. проблемам (1938). [4] А. А. Войткевич, Тр. Ин-та морфогенеза, 3 (1935). [5] А. А. Войткевич, Изв. Акад. Наук, биол. сер., № 2 (1939). [6] Л. А. Орбели, Природа, № 4 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1939. Volume XXII, № 6

ANIMAL PHYSIOLOGY

CHANGES IN BLOOD VALUE OF DRAFT HORSES DURING WORK AND REST*

By H. F. KUSHNER

(Communicated by N. I. Vavilov, Member of the Academy, 4. I. 1939)

The physiological processes of the organism during physical work, fatigue or rest are attracting the attention of scientists of various specialities. As is well known, the resistance of the muscle to fatigue depends on the power of the blood it is supplied with to oxidize the toxic products formed by the muscle at work. Hence, along with the study of the biochemical processes going on in an isolated muscle at work, it is of great interest to analyze the changes proceeding during work in the most important tissue of the organism, viz., in the blood.

There is quite a voluminous literature on the subject of the changes in the red blood and its acid base balance during work. A number of experiments made on human material and on agricultural and laboratory animals ([4,5,7,9,15,16,17,18,26,27]) have clearly shown that during light or moderate work there is a regular increase in the haemoglobin content and the number of erythrocytes, at the expense of those being supplied from the spleen. On the other hand, there are indications ([8,11,12,14,20,22,24]) showing that during strenuous exhaustive work the haemoglobin value and number of erythrocytes begin to fall below the normal and the blood reaction shows higher acidity.

In our present investigation we set ourselves the aim to find out the nature of blood value changes of draft-horses pulling different loads and also what are the blood value changes in horses classed as best and inferior.

Our material included 13 stallions born in 1936: 7 Brabançons and 6 Ardennes. The stallions were brought to the Moscow Hippodrome in August last year from studfarms No 64, 98 and 23. Until the middle of November last year the stallions were trained for the test which took place on November 10 and 11. On the first day the horses were tested for speed in carrying loads (for the Ardennes the load was 2 tons, for the Brabançons, 2.25 tons) for a distance of 10 km at a steady pace. After the test the horses were rested for 45 min. and then tested again for speed in a 5 km run at a trot without load. On the second day the horses were tested for maximum load hauls, the Ardennes preliminarily carrying a load of 4 tons and the Brabançons a load of 4.5 tons for a distance of 1 km. The tests were made at the Moscow Hippodrome on a gravel path at wet weather. Blood for analysis was always

* The training and testing of the horses were conducted by the chief expert of the All-Union Institute for Studfarming, S. G. Beniamson. In taking blood analyses and working up the material the author was assisted by O. N. Kitaieva and Ch. B. Alperovich.

taken from the jugular vein as follows: 1) on September 13, 1938, that is two or three weeks after the stallions arrived at the hippodrome; 2) on first day of test: a) during rest before the test, b) 2 or 3 min. after the load was carried 10 km at a steady pace, c) 2 or 3 min. after the 5 km run at a trot, d) after the 45 min. rest; 3) on the second day of test: a) 2 or 3 min. after the test for maximum load hauls, b) after the 45 min. rest.

The analyses of blood were taken for haemoglobin value by the Sahli method, for number of erythrocytes in Thoma-Zeiss cameras and for alkalinity by the Nevodov method. The diameter of the erythrocytes was determined by dry undyed smears, 100 erythrocytes of each being measured.

A remarkable property of the blood is the stability of its active reaction. This stability is known to depend upon the presence of a number of buffer systems which neutralize the excessive accumulation of acids. To a considerable extent the buffer power of the blood is determined by the properties of the haemoglobin. Oxyhaemoglobin, being a stronger acid than haemoglobin, when turning into the latter, releases a certain quantity of alkali which binds carbonic acid present even in moderate concentrates (5 or 6 mm of the mercury column). When the CO_2 pressure in the blood reaches 15 mm (during strenuous work) the haemoglobin may bind CO_2 directly without passing into oxyhaemoglobin. In the main these properties of haemoglobin determine the capacity of the organism to maintain the acid base balance. According to data by Van Slyke from 75 to 80% of the general buffer power of whole blood is determined by haemoglobin, while all the other buffers (bicarbonates, phosphates and proteins of plasma) make up not more than 20 or 25% of the total capacity of the blood to neutralize acid.

A good many works have been written on the changes in the buffers of the plasma during work ([8], [11], [12], [22], [20], [24]). They take, however, no account of the buffer power of haemoglobin; they show that a definite decline sets in in the buffer content of the plasma during strenuous work. Quite extensive experiments were made on horses by A. S. Solun ([6]). The studies he has made of the trotters at the Moscow Hippodrome have shown that after racing the alkalinity reserve of the plasma dropped from 57.46 to 24.52 cm^3 CO_2. Draft horses showed similar changes during strenuous work.

In our studies of the alkalinity of the whole blood we, on the contrary, established the total capacity of the blood to neutralize acid by titration in accordance with Nevodov's method, thus taking account of the buffer properties of haemoglobin too.

The results of our analyses are given in a summarized form in Table 1 and figure.

What strikes one in glancing at the figures of this table is the considerable increase in the number and diameter of erythrocytes, as well as in alkalinity of the blood in both breed groups, as shown by the analyses on day of test compared to the initial blood values shown in September.

We are inclined to ascribe these facts to the favourable influence of a two months' training that creates in the organism conditions intensifying the oxidation processes in the muscles. The data by Davis and Brewer ([10]) also confirm it. These authors have observed a considerable increase in the total amount of blood as well as in the number of erythrocytes per cubic mm in dogs which have undergone a long training. There are indications showing that training also causes an increase in the reserve alkalinity of the blood ([10], [21], [25]). Finally, data by Thörner ([25]) on the increase in the resistance power of the erythrocytes as a result of training and also the data given by us in Table 1 on the increase of diameter of the erythrocytes tend to show that in these cases the erythrocytes are of more recent origin, that is, that training intensifies the processes of blood forming.

Table 1

Blood Picture of Horses during State of Rest and Changes in Blood Components during Work and Rest

	Brabançons				Ardennes			
	Haemoglobin in % Sahli	Number of erythrocytes in millions	Alkalinity in mg %	Diameter of erythrocytes in μ	Haemoglobin in % Sahli	Number of erythrocytes in millions	Alkalinity in mg %	Diameter of erythrocytes in μ
In state of rest, 13.IX. 1938 .	65.6	8.53	448	5.35	66.6	8.50	490	5.36
In state of rest on first day of test, 10.XI 1938	65.2	9.04	554	5.43	67.0	9.03	566	5.47
Variations with regard to figures recorded on first day of test in per cent:								
a) after carrying a load of 2—2.25 tons for a distance of 10 km at a steady pace	18.1	7.2	4.7	— 1	15.6	14.1	5.1	0
b) after a 5 km run at a trot without load	21.1	11.1	2.6	— 1.5	25.1	26.7	1.5	—0.4
c) after 45 min. rest	5.2	—7.2	— 3.4	— 1.2	2.8	— 7.9	—14.5	—1.5
d) after test for maximum load hauls	33.5	24.6	—11.5	0	27	28.5	—22.3	—0.8
e) after 45 min. rest	—2	—5.4	—17.9	0.2	— 5.8	— 4.8	—33.2	—1.5

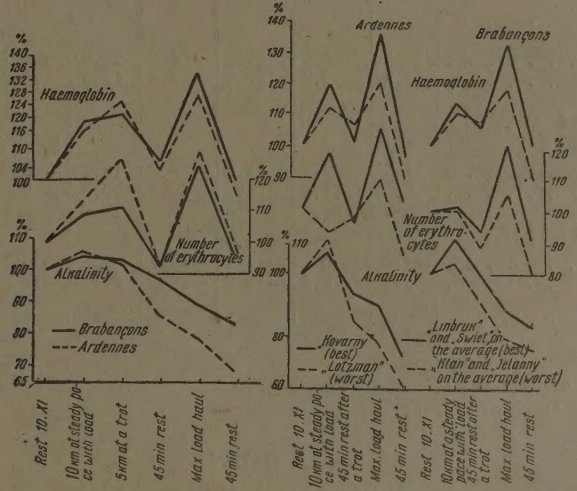
Furthermore Table 1 enables us to reveal the typical differences in the changes of blood values under various loads. The increase in the number of erythrocytes and haemoglobin content during the test for the 10 km load haul at a steady pace was comparatively less than during the 5 km run at a trot without load. A considerably greater increase in both these blood values was observed during the test for maximum load hauls. During the 45 min. rest both blood values have shown a sharp decrease and after the test for maximum load hauls remained even somewhat below the original figure. As to the total alkalinity of the blood, the load haul test at a pace and in the run at a trot have but slightly affected the respective values; however, after a 45 min. rest they have dropped below the normal. The test for maximum load hauls has shown a considerable reduction in the alkalinity of the blood and in the course of the next 45 min. rest the alkalinity continued to drop. We thus observe that 45 min. rest is by far inadequate to restore the normal blood value after putting the horses to such strenuous work, as that during the test for maximum load hauls.

Our data furthermore throw some light on the question as to the concentration of the haemoglobin in the erythrocytes emitted into the blood from the spleen at working time. On this question literary data are contradictory. While some data ([4], [16], [19], [23]) permit of asserting that the erythrocytes emitted into the blood from the spleen on the average reduce the haemoglobin concentration in one red blood cell, other indications show the opposite ([9],[13],[26]).

The animals investigated by us showed the following picture: while in the case of the Ardennes the changes in haemoglobin content and in number of erythrocytes during work run almost parallel, in the case of the Brabançons the increase in haemoglobin is higher than the respective changes in the number of erythrocytes, thereby confirming the view that there is a higher concentration of haemoglobin in the reserve erythrocytes. As we may see,

the reply to this question cannot be one and the same for all animals. Evidently there are definite differences in the changes of blood in various species and even in different specimens, and these differences account for the contradictory views of various authors in the question of haemoglobin concentration in the reserve erythrocytes.

Now we have only to analyze and compare the blood picture of the horses which as a result of the tests were classed as best and inferior. Taking as a basis the results of the tests for maximum load hauls with which the results of the tests for speed pretty closely coincided, we find that among the Ardennes «Kovarny» took first place and «Lotzman» fifth («Linkor» which took



sixth place is not taken into account, since, for technical reasons, the analysis of blood could not be taken 2 or 3 min. after the test, but only 13 min. after the finish). Among the Brabançons first and second place were taken by «Linbruk» and «Swiet» respectively, and fifth and sixth place respectively by «Klan» and «Jelanny» (Table 2 and figure).

Thus, we may see that the differences in the shifts of the blood value of the best and inferior horses are rather considerable. The increase in the number of erythrocytes and in the haemoglobin value of the best horses was considerably higher than that of the inferior horses. Furthermore during rest the restoration of the normal blood values in the case of the best horses proceeded much more rapidly than in the case of the inferior horses. It is noteworthy that the loss of alkalinity in the case of the horses which won the foremost places at the tests was considerably less than in the case of the inferior horses. There is yet another circumstance which strikes our attention. The stallions Maryazhny (Brabançon) and Lazutchik (Ardennes) occupied medium places, although they showed considerable increases in blood values during load tests. This, we believe, is to be explained by their low initial blood values. Investigated before test in a state of rest these horses occupied the last places for number of erythrocytes, haemoglobin value and alkalinity. It is obvious that these horses being in an anaemic state at the start could not very well compete with the others even though their blood values showed considerable increases during strenuous work.

Table 2

Variations in Blood Values of the Best and Inferior Horses during Work and Rest in % (blood values of the horses at the initial state of rest on first day of tests were taken as 100%)

Blood value	Brabançons				Ardennes			
	Load haul at a steady pace	45 min. rest	Maximum load haul	45 min. rest	Load haul at a steady pace	45 min. rest	Maximum load haul	45 min. rest
Haemoglobin:								
Best horses	14.0	6.4	34.2	0.5	20.0	1.1	37.0	— 3.6
Inferior horses	11.2	7.8	19.2	— 8.1	12.5	6.5	20.0	—10.3
Number of erythrocytes:								
Best horses	1.5	— 6.5	21.5	— 8.8	18.5	— 5.0	26.5	2.0
Inferior horses	0.95	—11.1	5.7	—19.6	—7.0	— 2.3	10.0	—14.0
Alkalinity:								
Best horses	11.0	0	—11.1	—16.7	6.6	— 6.5	—10.0	—26.5
Inferior horses	3.3	— 8.3	—19.9	—23.3	10.5	—14.5	—21.5	—35.5

Institute of Genetics.
Academy of Sciences of the USSR.
Moscow.

Received
5. I. 1939.

REFERENCES

[1] А. Лантош и др., Клин. медицина, № 11 (1933). [2] А. Неводов, Лаборат. практика, № 3 (1930). [3] Н. Озерский и М. Малышев, Практ. ветеринария, № 2 (1931). [4] Л. Пирогов и др., Внутр. качества лошадей (1929). [5] Н. Преображенский и Н. Шпайер, Тр. Моск. зооветин-та, II (1935). [6] А. Солун, Научно-агрономич. журн., № 6 (1929). [7] К. Стогов, Практ. ветеринария, № 1 (1929). [8] J. Barcroft, The Respiratory Function of the Blood (1914). [9] W. Bogdanow u. and., ZS. f. Züchtung, **31** (1934). [10] J. Davis a. N. Brewer, Amer. J. Physiol., **113** (1935). [11] Er. Duluge, Ber. u. d. ges. Biol., **105** (1938). [12] J. Eftimesku, ZS. f. Züchtung, **19** (1930). [13] N. Germanow, ibid., **30** (1934). [14] W. Gross u. O. Kestner, ZS. f. Biol., **70** (1920). [15] P. Hawk, Amer. J. Physiol., **10** (1903—04). [16] H. Keese, Bioch. ZS., **178** (1926). [17] Ed. Laug, Amer. J. Physiol., **107** (1934). [18] L. Nice a. oth., ibid., **108** (1934). [19] L. Nice, ibid., **119** (1937). [20] W. Pride a. oth., Amer. J. Obstet. Gyn., **35** (1938). [21] Sattleger, ZS. f. Züchtung, **23** (1931). [22] A. Scheunert u. and., Pfluger's Archiv, **212** (1926), **213** (1926), **215** (1927), **216** (1927). [23] Ed. Schneider a. C. Crampton, Amer. J. Physiol., **112** (1935). [24] F. Schlutz a. oth., ibid., **111** (1935). [25] W. Thörner, Arbeitsphysiologie, **2** (1929), **5** (1932). [26] O. Walters, Amer. J. Physiol., **108** (1934). [27] O. Walters, Fol. haematol., **56** (1937).

PRIX D'ABONNEMENT

Un an — 36 livraisons . . . . $ 15.00. Frs. fr. 250.00. £ 2.8.0
Six mois — 18 livraisons . . . $ 7.50. Frs. fr. 125.00. £ 1.4.0
(Séparément $ 0.50. Frs. fr. 8.00. £ 0.1.6 le numéro)

URSS — MEZDUNARODNAJA KNIGA, 18, Kuznetskij Most, Moscou (Compte courant n° 263 Banque d'Etat de l'URSS, 12, Neglinnaja, Moscou).
U. S. A., NORTH and SOUTH AMERICA — BOOKNIGA CORPORATION. 255 Fifth Avenue. New York, N. Y.
ENGLAND — W. H. SMITH & son, Ltd. Strand House, Portugal Str. London W. C. 2.
COLLET'S Foreign Department. 31 Gerrard Street, London W. 1.
FRANCE — MESSAGERIES HACHETTE. Service Abonnements. 111, Rue Réaumur. Paris, 2e.
SUISSE — Buchhandlung STAUFFACHER (Genossenschaft). Hauptpost-Fach 43. Zürich.
ESPANA — „DISTRIBUIDORA DE PUBLICACIONES". Diputacion, 260. Barcelona.
Ç. S. R. — MELANTRICH, Akc. Spol. Knihkupectvi — odd. slovanských knih. Václavské nám 42. Praha II. (Účet pošt. spoř. 20. 208).
BELGIQUE — OBLA (Office Belge Littéraire et Artistique). 6/8/10, rue Duquesnoy. Bruxelles.
LIETUVA — „MOKSLAS". Knygynas. Laisves Aleja, 46. Kaunas.
— SPAUDOS FONDAS. Laisves Al. 62. Kaunas.
TURQUIE — LIBRAIRIE HACHETTE. Succursale de Turquie. 469, Avenue de l'Indépendance. Boite Postale Pera 2219. Istanbul.
DEUTSCHLAND — KOEHLER & VOLCKMAR, A/G. Russland-Abteilung. Postfach 173. Leipzig C. 1.
POLSKA — GEBETHNER & WOLFF. Filja I. Krakowskie Przedm. 15. Warszawa.
ROSSICA. Chmielna 5. Warszawa.
PALESTINE — SAFRAN CO. Jaffa Rd. 36. P. O. B. 223. Haifa.
LATVIJA — VALTERS un RAPA Akc. Sab. Teatra iela 11. Riga (Pasta tek. rek. № 675).
K/s „LAIKMETS". Terbatas iela 37. Riga.
SVERIGE — C. E. FRITZE's Kgl. Hofbuchhandlung. Fredsgatan 2, Stockholm.
A. B. WENNERCRENS WIILIAMS Box 657, Stockholm 1.
AUSTRALIA — MODERN PUBLISHERS Ltd., 124 Oxford Street. Sydney.
BULGARIA — T. F. TSCHIPEFF. Buchhandlung Boulevard Dondoukoff 20/22 Sofia. (Postscheckkonto-Sofia 540).
NORGE — JOHAN GRUNDT TANUM. Tidligere Aschehougs Boghandel. Karl Johans gt. 43. Oslo.
ROMANIA — Biroul Central de Presa „LUVRU". Strada Oltuz, 14, Bucuresti 1.
EESTI — TÖÖKÖÖL, Pärnu mnt. 28, Tallinn.
DÄNEMARK — S. U. V. s Boghandel. Frederiksbarggade 42¹. Kopenhagen. K.

Les «Comptes Rendus», largement expédiés à l'étranger dans les centres scientifiques les plus importants et dans les bureaux de nombreuses revues, sont le seul organe scientifique en URSS, donnant tous les dix jours un compte rendu des plus récentes acquisitions de la science soviétique.

Prix $ 0.50.